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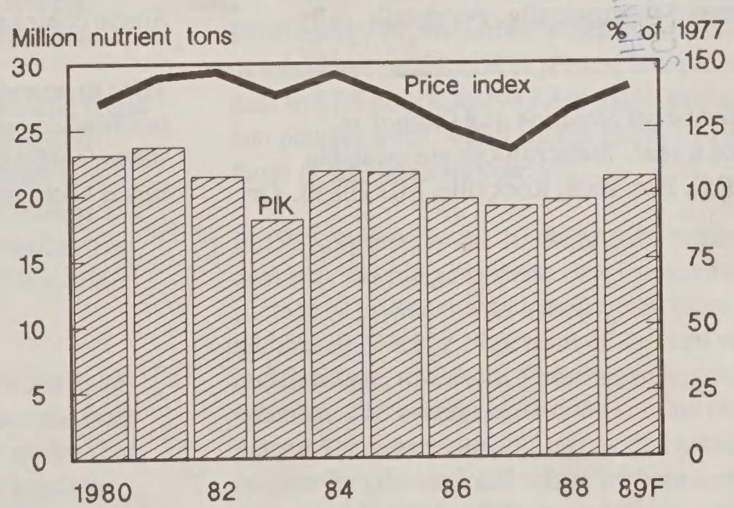
Situation and Outlook Report

Fertilizer Consumption and Prices To Rise



1989 forecast.

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SUMMARY

U.S. plant nutrient consumption during July 1988/June 1989 is forecast to rise 9 percent over a year earlier because of expected increases in planted acreage and crop prices. Use of nitrogen, phosphate, and potash will likely be 11.5, 4.4, and 5.3 million tons, up 10, 8, and 7 percent, respectively, from a year earlier. Total planted acreage for the eight major field crops will probably go up 4 to 11 percent, with the largest gains expected for corn and wheat, the major fertilizer-using crops. Application rates will probably increase somewhat for corn, soybeans, and wheat, but could fall for cotton.

Domestic nitrogen and phosphate fertilizer supplies are expected to tighten because of increased consumption, and this tightening will drive up prices. By spring, the fertilizer price index is projected to be 7 percent above a year earlier, after rising 2 percent from April to October 1988. Nitrogen prices will likely show the greatest increase since last fall; supplies should be adequate if expected gains in imports and domestic production materialize. Phosphate supplies, at moderately higher prices, should also be sufficient, since the rise in U.S. and foreign demand will be met by higher domestic production. Increased farm demand for potash, at stable to slightly higher prices, will be satisified by greater domestic production and imports.

World plant nutrient use rose an estimated 2 percent in 1987/88. Worldwide growth in fertilizer production, consumption, and trade will likely continue over the next several years, with a tightening of the supply and demand balance placing upward pressure on world prices. Fertilizer production and consumption will probably increase only slightly in the developed market economies, while showing greater expansion in the developing market economies of Latin America and Asia. Many of these countries are working toward self-sufficiency in food and fertilizer production.

By the early 1990's, world growth in nitrogen demand could exceed supply, leading to higher prices. The developed countries will likely have excess phosphate fertilizer supplies, while the Soviet Union, Asia, and Eastern Europe will be deficit areas. The greatest potash surplus is forecast for North America, while Western Europe, Asia, Africa, and Latin America are projected to be deficit areas.

Pesticide use on major field crops in 1989 is forecast to be 470 million pounds of active ingredients, up 7 percent from 1988. Planted corn acreage, on which large amounts of herbicides are used, will likely surpass year-earlier levels in 1989 by 9 to 15 percent. The proportion of all crop acres treated with herbicides in 1988 remained fairly stable, but more soybean acreage was treated with insecticides to combat spider mite infestations.

Spring herbicide, insecticide, and fungicide prices may be up 5, 4, and 2 percent, respectively, in 1989. These increases come on the heels of a 3- to 4-percent rise in 1988. Overall domestic availability of pesticides is expected to dip 1 percent in 1989, but should still meet expanded consumption.

In the 1987/88 crop marketing year, seed use for the eight major crops was 5.9 million tons, slightly higher than the previous year. Total seed use for 1988/89 is projected to be up 8 percent from the previous year due to the expansion in planted acreage. Higher seeding rates increased the average seed cost per acre for most of the major field crops in 1988. The prices paid index for seeds will likely rise 10 to 15 percent in 1989. Prices of field seeds, especially corn and soybeans, should increase significantly due to drought-reduced supplies and greater demand. Supplies of grass seed are expected to be adequate because production was not greatly affected by the drought. Continued Conservation Reserve Program demand could put upward pressure on grass seed prices.

The U.S. trade surplus in planting seeds dropped to $229 million in 1987, showing a decline for the second consecutive year. Sharp increases in forage seed imports, combined with decreases in corn and grain sorghum seed exports, accounted for the trade balance decline.

Despite the drought, 1988 farm machinery expenditures rose an estimated 5 to 10 percent over 1987. A similar increase is likely in 1989, when expenditures could reach $6.4 to $7.1 billion. Sales of most types of new farm machinery remained stable or went up in 1988, except for a 16-percent fall in combine sales. If severe weather does not interfere, sales of all major classes of new farm machinery should increase in 1989.

Farm energy expenditures, which comprise about 5.5 percent of total farm production expenses, will probably jump 7 percent to $7.5 billion in 1989 due to increases in energy prices and planted acres. Farm energy prices in 1988 resembled those of the previous year.

In 1987, farmers in the 10 major corn-producing States used conventional tillage systems on 81 percent of their corn acreage (21 percent with a moldboard plow and 60 percent without it). Nearly 14 percent of the corn was produced with mulch tillage, and about 5 percent was grown with no-till systems. The average remaining residue after planting was 2 percent for conventional tillage with a moldboard plow, 14 percent for conventional tillage without a moldboard plow, 36 percent for mulch tillage, and 63 percent for no-till. The average amount of time spent per acre in tillage and planting was .79 hours for conventional tillage with a moldboard plow, .44 for conventional tillage without a moldboard plow, .29 for mulch tillage, and .16 for no-till.

Labor-saving technologies and higher nonfarm wages have reduced total labor input on farms from about 19.3 billion hours in 1950 to 5.5 billion in 1986. Wages have risen faster than prices of other farm inputs, such as agricultural chemicals, making these other inputs economical substitutes for labor. Labor expenditures nevertheless made up 11 percent of total cash operating expenses in 1986.

FERTILIZER

Demand

The 1988 drought will lead to sharp reductions in carryover stocks for a number of major U.S. crops; production levels for wheat, soybeans, corn, and other feed grains are down significantly. The tighter crop supplies have resulted in higher prices for most major U.S. crops than a year earlier. In addition, the 1989 acreage reduction programs (ARP) for wheat and feed grains have been reduced, and paid land diversions have been eliminated. Consequently, acreage planted to the major field crops in 1989 is expected to increase significantly over 1988. This will result in the first substantial gain in fertilizer use since 1984, when use rebounded as PIK-diverted acreage was returned to production.

Acreage of the eight major field crops is projected to rise by 4 to 11 percent, with especially large increases expected in planted areas of corn and wheat, the major fertilizer-using crops (table 1). Corn area, which typically accounts for over 40 percent of total primary nutrient consumption, is expected to rise between 9 and 15 percent in 1989. Planted wheat acreage, which typically accounts for an additional 10 percent of primary nutrient use, is likely to expand 10 to 16 percent over 1988. Additional increases in planted area are expected for soybeans, sorghum, and barley.

The projected expansion in crop acreage and stable-to-increased application rates for corn, soybeans, and wheat are expected to lead to a significant increase in fertilizer use in 1988/89 (July 1-June 30). U.S. plant nutrient use is forecast to increase to 21.2 million tons, rising 9 percent from the 19.5 million tons used in 1987/88. Use is forecast at 11.5 million tons for nitrogen, 4.4 million for phosphate, and 5.3 million for potash. During 1987/88, farmers used 10.5 million tons of nitrogen, 4.1 million of phosphate, and 4.9 million of potash.

Table 1.--Acreage assumptions underlying 1989 input use forecast

Crops	1988 actual	1989 forecast
	Million planted acres	
Wheat	65.5	72.0 - 76.0
Feed grains:	101.6	106.8 - 114.8
Corn	67.6	74.0 - 78.0
Other 1/	34.0	32.8 - 36.8
Soybeans	58.9	60.0 - 63.0
Cotton	12.5	10.0 - 11.0
Rice	2.9	2.6 - 3.0

1/ Sorghum, barley, and oats.

Fertilizer application rates are influenced by both economic and agronomic considerations. Determining how much fertilizer to apply per acre to this year's crops will be somewhat more complicated in some areas of the country, however, because nutrients may have been carried over in the soil from the drought-stunted 1988 crop. Potassium and phosphorous are relatively immobile in most soils, and therefore 1989 application rates should reflect the unused portion of these nutrients applied last year. Nitrogen, however, is much less stable, with carryover affected by soil type, organic matter, denitrification, and leaching, which depends on the amount and distribution of precipitation between harvest and spring planting. Consequently, extension personnel are recommending that a soil test be taken before spring fertilizer application begins.

While nutrient carryover will exert downward pressure on 1989 application rates, declines for some crops may be offset by other factors. Although spring 1989 fertilizer prices are likely to exceed a year earlier, prices at planting for corn, soybeans, and spring wheat are also expected to be up significantly. Winter wheat prices were up over 50 percent at planting this fall. Consequently, fertilizer nutrient application rates in 1989 for corn, soybeans, and wheat will probably be somewhat higher than in 1988, especially for nitrogen. In contrast, lower cotton prices, resulting from an increase in carryover stocks, may lead to lower per-acre fertilizer rates in 1989.

Exports of nitrogen fertilizer during 1988/89 are projected to decrease from a year earlier as exports of most major nitrogenous materials, particularly anhydrous ammonia, decline due to increased domestic use and foreign competition. Overall, nitrogen exports are expected to fall by 9 percent as greater ammonium phosphate exports limit further declines. Phosphate exports may rise 8 percent in 1988/89 if diammonium phosphate shipments to Asia remain strong. Potash exports could be reduced by as much as 25 percent as shipments to South America decline.

Supplies

Domestic supplies of nitrogen fertilizer will be tight this spring, but should be adequate to meet 1989 crop needs if imports and domestic production exceed a year earlier, as expected. U.S. phosphate supplies should also be sufficient because the increase in domestic demand will be met by higher production. Domestic potash supplies will be ample

because rising domestic production and reduced exports will supplement increased imports from Canada.

Some regional shortages of fertilizer materials may occur, however, due to potential problems in the U.S. transportation system. The peak time for fertilizer shipments, February through March, coincides with the time many U.S. waterways are frozen and most long-haul movements must be made by rail. In the last few years the U.S. rail system has occasionally been plagued by hopper car shortages during peak demand periods. Although seasonal demand factors are believed to be primarily responsible for the shortages, the number of hopper cars used for grain has also declined somewhat since 1983. Waterways may remain closed into the spring due to lower water levels caused by last year's drought, thus increasing the use of rail service. Additional demand will be placed on the system if increased grain exports to the Soviet Union materialize. Even in the absence of fertilizer shortages, if increased transportation costs result in some areas, they will be passed on through higher fertilizer prices.

U.S. fertilizer production capacity will be more fully utilized in 1988/89 for all three primary nutrients as producers continue to respond to higher prices and increased use. Production rates for July-November 1988 indicate that 98 percent of U.S. anhydrous ammonia capacity, estimated at 16.8 million tons, was being used. Wet-process phosphoric acid facilities capable of producing almost 12 million tons operated at over 97 percent of capacity through November. U.S. potash capacity (recently increased to 2.1 million tons) operated at an 81-percent rate and Canadian capacity (12.3 million tons) operated at 69 percent. A year earlier, anhydrous ammonia plants operated at 92 percent of capacity, while wet-process phosphoric acid facilities operated at about 96 percent. Operating rates for U.S. and Canadian potash producers stood at 78 and 59 percent, respectively.

U.S. nitrogen production is projected to increase by 2 percent in 1988/89; anhydrous ammonia producers are expected to operate at maximum capacity at least until spring (table 2). Through most of 1988, domestic producers benefited from relatively stable natural gas prices, approaching the lowest levels of the decade. Since mid-December, however, gas prices have increased as producer contracts expired and supplies tightened due to seasonal demand. On the other hand, wholesale ammonia prices have also risen substantially since October, encouraging increased production.

Nitrogen exports will decrease as more domestic product is used to satisfy greater crop needs and imports will rise to meet the projected increase in domestic use. Consequently, U.S. nitrogen imports are forecast to increase 14 percent in 1988/89. Increased nitrogen shipments will likely come from the Soviet Union and Trinidad-Tobago. Canada will continue to be the major U.S. supplier of nitrogen, but shipments are not likely to show a significant gain over 1987/88 because Canadian fertilizer demand is forecast to rise 6 to 7 percent (1).

In 1987/88, U.S. nitrogen fertilizer production increased in response to higher prices and increased use. Anhydrous ammonia production rose 9 percent to 16.4 million tons, while urea production increased 14 percent to 7.6 million (table 3). Increases in production of other nitrogen materials ranged from 5 percent for ammonium nitrate to 19 percent for nitrogen solutions.

U.S. phosphate production is expected to rise about 5 percent in 1988/89 in response to higher prices resulting from greater domestic demand and continued strength in the export market. Total production of selected phosphate fertilizer materials in 1987/88 increased 11 percent from a year earlier. Diammonium phosphate production, which accounts for the largest proportion of total U.S. phosphate fertilizer

Table 2.--U.S. supply-demand balance for years ending June 30

Item	Nitrogen			Phosphate			Potash		
	1987	1988	1989 1/	1987	1988	1989 1/	1987	1988	1989 1/
	Million nutrient tons								
Producers' beginning inventory	1.88	1.36	1.37	0.63	0.51	0.55	0.29	0.22	0.16
Production	12.41	13.48	13.72	10.16 2/	11.35 2/	11.87 2/	1.34	1.52	1.67
Imports	3.81	3.98	4.52	0.11 2/	0.16 2/	0.12 2/	4.35	4.74	4.94
Total available supply	18.10	18.83	19.60	10.90	12.01	12.54	5.99	6.48	6.77
Agricultural consumption	10.21	10.48	11.51	4.01	4.11	4.43	4.84	4.94	5.31
Exports	2.71	3.03	2.76	4.28 2/	4.11 2/	4.45 2/	0.65	0.54	0.40
Total agricultural and export demand	12.92	13.50	14.27	8.29	8.22	8.88	5.48	5.48	5.71
Producers' ending inventory	1.36	1.37	1.40	0.51	0.55	0.60	0.22	0.16	0.20
Available for non-agricultural use	3.83	3.95	3.93	2.10	3.23	3.06	0.29	0.83	0.86

1/ Forecast. 2/ Does not include phosphate rock. In addition, does not include exports of superphosphoric acid because of a data reporting change by the U.S. Department of Commerce in July 1985. Thus, phosphate exports are understated and domestic supply is overstated.

Source: (2, 3, 6, 7, 8).

Table 3.--U.S. production of selected fertilizer materials for years ending June 30

Material	1987	1988 1/	Annual change
	1,000 tons		Percent
Nitrogenous fertilizers: 2/			
Anhydrous ammonia 3/	15,132	16,443	9
Ammonium nitrate, solid	1,827	1,921	5
Ammonium sulfate	2,100	2,242	7
Urea 3/	6,667	7,606	14
Nitrogen Solutions	2,225	2,652	19
Phosphate fertilizers: 4/			
Normal and enriched superphosphate	76	99	31
Triple superphosphate	1,026	955	-7
Diammonium phosphate	4,623	5,218	13
Other ammonium phosphates and other phosphatic fertilizer materials	924	1,113	20
Total 5/	6,650	7,385	11
Wet-process phosphoric acid 6/	9,557	10,661	12
Muriate of potash: 7/			
United States	1,344	1,520	13
Canada	7,751	8,642	11

1/ Preliminary. 2/ Total not listed because nitrogen solutions are in 1,000 tons of N, while other nitrogen products are in 1,000 tons of material. 3/ Includes material for nonfertilizer use. 4/ Reported in 1,000 tons P2O5. 5/ Totals may not add due to rounding. 6/ Includes merchant acid. 7/ Reported in 1,000 tons of K2O.

Source: (2,8).

production, rose 13 percent, while production of other ammonium phosphates and normal and enriched superphosphate also increased. In contrast, triple superphosphate production declined 7 percent.

In 1988/89, U.S. potash production will likely increase by 10 percent as greater domestic demand more than offsets the anticipated decline in exports. U.S. potash imports are expected to increase 4 percent in 1988/89 as Canadian suppliers regain some of the market share they lost to Israel in 1987/88. Both U.S. and Canadian producers stepped up production in 1987/88 because the agreement to end the antidumping case against Canadian potash producers resulted in record prices paid by farmers for potassium chloride.

Farm Prices

Tighter supplies due primarily to greater U.S. fertilizer demand in 1988/89 will raise aggregate fertilizer prices. The prices paid index for fertilizer in spring 1989 is expected to average 5 percent above the October 1988 level and 7 percent above a year earlier. Nitrogen prices will likely show the greatest increase since last fall as domestic supplies tighten. Phosphate prices will also rise as domestic demand increases and the export market demonstrates continued strength. Potash prices should rise only slightly; the price of potassium chloride is not expected to rise much beyond $160 per ton since market supplies appear to be ample to meet higher domestic demand.

For the second consecutive year, average farm fertilizer prices have exhibited an uncharacteristic spring-to-fall increase. Although the farm price of some fertilizer products changed little from April to October 1988, the prices paid index was up almost 2 percent by October (table 4). Price increases for urea, ammonium nitrate, and ammonium sulfate were partially offset by an 8-percent decline in the price of anhydrous ammonia. The typical seasonal pattern for farm fertilizer prices will likely be repeated in 1989, however, because the tightness in nitrogen and phosphate supplies should ease by the fall.

The proposed reclassification of anhydrous ammonia from a nonflammable to a poisonous gas, formally announced by the U.S. Department of Transportation (DOT) in May 1987, is still under review. DOT reopened the comment period after receiving more than 700 protests against the reclassification, and indicated that action on the proposal would probably be delayed until late 1989.

To simplify and reduce the number of regulations governing the packaging and transportation of hazardous materials and facilitate international commerce, DOT proposed the reclassification of anhydrous ammonia (currently treated as a poisonous gas in international shipments governed by United

Table 4.--Average U.S. farm prices for selected fertilizer materials 1/

Year		Anhydrous ammonia (82%)	Urea (44-46%)	Triple superphosphate (44-46%)	Diammonium phosphate (18-46-0%)	Potash (60%)	Mixed fertilizer (6-24-24%)	Prices paid index 1977=100
		Dollars per ton						
1984:	May	280	227	231	271	147	217	147
1985:	May	252	217	203	240	128	192	135
	October	237	204	195	229	113	182	130
1986:	April	225	174	190	224	111	179	125
	October	174	159	182	205	107	173	116
1987:	April	187	161	194	220	115	176	117
	October	180	159	206	231	135	183	121
1988:	April	208	183	222	251	157	208	132
	October	191	188	221	246	157	208	134

1/ Based on a survey of fertilizer dealers conducted by the National Agricultural Statistics Service, USDA.

Nations standards). However, opponents of the reclassification believe that it could have a significant impact on product shipping, transportation routes, insurance rates, and marketing costs. Any increased costs will likely lead to higher anhydrous ammonia prices, encouraging farmers to switch to other nitrogen sources like urea. Opponents have also voiced the concern that the use of the poison label's skull and crossbones could result in a negative public perception of the fertilizer industry. Consequently, many opponents support a reclassification of anhydrous ammonia to a corrosive gas, a classification already adopted by Canada.

U.S. Fertilizer Trade

Fertilizer import volume in 1987/88 rose about 3 percent from a year earlier, while value increased almost 22 percent (table 5). Imports totaled approximately 15.6 million tons (8.9 million nutrient tons) valued at $1.24 billion. Canada and the Soviet Union provided a substantial share of U.S. nitrogen imports, and Canada also provided most of the potash imports. Exports totaled 24.0 million tons (7.7 million nutrient tons), up about 1 percent from 1986/87 (table 6). Asian countries provided the largest markets, followed by Canada and Latin America. China received about 11 percent of all U.S. fertilizer exports; South Korea and Canada received over 14 and 16 percent, respectively, of phosphate rock exports.

Table 5.--U.S. imports of selected fertilizer materials

Material	Fertilizer year 1986/87	Fertilizer year 1987/88	July - November 1987	July - November 1988
	1,000 tons			
Nitrogen:				
Anhydrous ammonia	2,449	3,200	1,212	1,497
Urea	3,020	2,155	586	709
Ammonium nitrate	440	238	66	87
Ammonium sulfate	315	290	67	132
Sodium nitrate	97	122	26	44
Calcium nitrate	153	169	44	58
Nitrogen solutions	517	595	125	161
Other	171	108	27	40
Total	7,162	6,877	2,153	2,728
Phosphate:				
Ammonium phosphates	142	125	55	43
Crude phosphates	533	544	226	385
Phosphoric acid 1/	1	1	*	1
Normal and triple superphosphate	27	146	29	*
Other	2	1	*	*
Total	705	817	310	429
Potash:				
Potassium chloride	7,066	7,673	2,591	2,652
Potassium sulfate	54	83	22	26
Potassium nitrate 2/	46	74	16	28
Total	7,166	7,830	2,629	2,706
Mixed fertilizers	120	111	13	16
Total	15,153	15,635	5,105	5,879
	Billion dollars			
Total value 3/	1.02	1.24	0.38	0.48

* = Less than 500 tons.

1/ Includes all forms of phosphoric acid. 2/ Includes potassium sodium nitrate. 3/ Value by fertilizer material in appendix table 1.

Source: (7).

Table 6.--U.S. exports of selected fertilizer materials 1/

Material	Fertilizer year 1986/87	Fertilizer year 1987/88	July - November 1987	July - November 1988
	1,000 tons			
Nitrogen:				
Anhydrous ammonia	1,062	953	482	335
Urea	790	1,133	551	520
Ammonium nitrate	258	120	57	29
Ammonium sulfate	1,031	943	410	352
Sodium nitrate	12	8	5	2
Nitrogen Solutions	123	806	551	508
Other	78	86	19	23
Total	3,354	4,049	2,075	1,769
Processed phosphate:				
Normal superphosphate	4	12	1	14
Triple superphosphate	1,724	1,194	594	451
Diammonium phosphate	5,918	6,414	2,919	3,238
Monoammonium phosphate	505	691	303	333
Other ammonium phosphate	78	25	9	28
Phosphoric acid 2/	921	448	149	182
Total	9,150	8,784	3,975	4,246
Phosphate rock 3/	9,933	9,980	4,039	4,163
Potash:				
Potassium chloride	797	528	262	165
Potassium sulfate	220	324	163	70
Other	213	240	87	104
Total	1,230	1,092	512	339
Mixed fertilizers	32	46	25	16
Total	23,699	23,951	10,626	10,533

1/ Declared value of exports not reported after 1985. 2/ Includes only wet-process phosphoric acid; superphosphoric acid reports were discontinued after 1985. 3/ Effective January 1984, phosphate rock exports include a small tonnage of miscellaneous fertilizers.

Source: (6).

In anticipation of increased U.S. planted acreage in 1989, fertilizer import volume during the first 5 months of fertilizer year 1988/89 (July-November) rose 15 percent (table 5). Exports decreased 1 percent compared to a year earlier (table 6). Imports of anhydrous ammonia, urea, and nitrogen solutions went up 24, 21, and 29 percent, respectively. Imports of potassium chloride, the major source of potash, increased 2 percent. Nitrogen and potash exports were down 15 and 34 percent, respectively; processed phosphates and phosphate rock exports were up 7 and 3 percent, respectively.

Nitrogen

Nitrogen imports in 1987/88 (material basis) decreased about 4 percent, while exports increased 21 percent. Increases in anhydrous ammonia and nitrogen solution imports of 31 and 15 percent, respectively, were offset by decreases in urea and ammonium nitrate imports of 29 and 46 percent, respectively. Urea imports declined to 2.2 million tons,

while anhydrous ammonia imports increased to 3.2 million. Anhydrous ammonia represented 47 percent of all nitrogen material imports, followed by urea (31 percent), nitrogen solutions (9 percent), and ammonium nitrate and ammonium sulfate (4 percent each).

In 1987/88 Canada remained the most important supplier of nitrogen fertilizers, providing about 46 percent of U.S. import tonnage. The Soviet Union ranked second with 13 percent; Mexico, Trinidad-Tobago, and Italy provided 4, 3, and 3 percent, respectively. Canada remained the major source of U.S. anhydrous ammonia imports, supplying 47 percent of the total, while the Soviet Union's share also increased slightly to 29 percent. Mexico's share increased from 1 to 6 percent, while Trinidad-Tobago's share declined from 15 to 12 percent. Canada supplied about 55 percent of the 2.2 million tons of urea imported by the United States in 1987/88, while Trinidad-Tobago provided another 12 percent.

In 1987/88, urea, nitrogen solutions, and diammonium phosphate exports rose 43, 555, and 8 percent, respectively; anhydrous ammonia shipments fell 10 percent (table 6). Overall nitrogen exports increased 21 percent. Urea exports accounted for 28 percent of the 4.1 million tons of nitrogen materials exported. Anhydrous ammonia represented 24 percent; ammonium sulfate, 23 percent; nitrogen solutions, 20 percent;, and ammonium nitrate, 3 percent. Diammonium phosphate (18 percent nitrogen and 46 percent phosphate) accounted for over 38 percent of the 4.1 million nutrient tons of nitrogen exported.

In 1987/88, South Korea, Belgium-Luxembourg, and Mexico were the largest customers for U.S. anhydrous ammonia, while Brazil was the largest customer for U.S. ammonium sulfate, purchasing 51 percent of the 0.9 million tons exported. China, Chile, and Canada purchased the most urea, representing 50, 16, and 6 percent, respectively, of the total exported. France purchased 65 percent of nitrogen solutions, making it the largest customer for this product.

Phosphate

At 8.8 million tons, U.S. phosphate fertilizer exports in 1987/88 declined about 4 percent from the previous year. However, they were still much higher than in 1985/86, an adverse fertilizer year. Exports of phosphoric acid, triple superphosphate, and other ammonium phosphates fell 51, 31, and 68 percent, respectively, while exports of diammonium phosphate and monoammonium phosphate rose 8 and 37 percent, respectively. Forty-six percent of all phosphoric acid exports went to India. Chile received about 20 percent of triple superphosphate exports. China received 2.1 million tons or 33 percent of diammonium phosphate exports, and Canada received 26 percent of all monoammonium phosphate exports. The Republic of Korea was the largest purchaser of U.S. phosphate rock, accounting for 16 percent of all exports, with Canada and Japan accounting for 14 and 10 percent, respectively.

China was the largest purchaser of U.S. processed phosphate fertilizer in 1987/88, accounting for 25 percent of the total. Other important customers were Canada and Japan with 9 percent each, Belgium-Luxembourg with 7 percent, and Chile, Italy, Turkey, and Pakistan with 4 percent each. Although data on exports of superphosphoric acid to the Soviet Union are not available, it is a large customer for U.S. phosphate fertilizer.

Potash

U.S. potassium chloride imports increased about 9 percent in 1987/88 to 7.7 million tons in response to higher domestic consumption (table 5). Potassium chloride accounted for almost all potash imports, with Canada providing 88 percent of the total, down from 95 percent the previous year. Israel and the Soviet Union were the only other significant suppliers, with 6 and 3 percent, respectively.

U.S. exports of potassium fertilizer materials decreased about 11 percent in 1987/88. Approximately 1.1 million tons were shipped, with potassium chloride accounting for 48 percent of the total (table 6). Potassium sulfate exports, which increased 47 percent and accounted for 30 percent of potassium materials, have continued to gain importance as an export item.

Fertilizer Use Estimates

The 1988 drought appears to have had little effect on fertilizer use in 1987/88. Most fertilizer is typically applied between March and June, thus preceding the first signs of a serious nationwide drought. Some side-dressing may have been postponed, however, and continued dry conditions in localized areas of the winter wheat belt may have curtailed applications last fall.

In the year ending June 30, 1988, 44.2 million tons of fertilizer material were used in the United States and Puerto Rico, up 3 percent from 1986/87 (table 7). In terms of total plant nutrients, use was up 2.5 percent to 19.5 million tons. Use of nitrogen and phosphate increased by 2.6 percent to 10.5 and 4.1 million tons, respectively, while use of potash increased by just over 2 percent to 4.9 million tons.

While overall fertilizer use increased in 1987/88, changes in regional consumption were more mixed. Plant nutrient use fell by as much as 12 percent in the Northeast but rose by as much as 14 percent in the Southern Plains due to changes in planted acreage in these regions (table 8). Nitrogen use increased in five regions—the Corn Belt, Mountain, Northern Plains, Pacific, and Southern Plains (table 9). Use of phosphate and potash increased in most regions; phosphate use

Table 7.--U.S. fertilizer consumption 1/

Year ending June 30 2/	Total fertilizer materials	Primary nutrient use				
		N	P2O5	K2O	Total 3/	Share of 1977 total
		Million tons				1977=100
1977	51.6	10.6	5.6	5.8	22.1	100
1980	52.8	11.4	5.4	6.2	23.1	104
1981	54.0	11.9	5.4	6.3	23.7	107
1982	48.7	11.0	4.8	5.6	21.4	97
1983	41.8	9.1	4.1	4.8	18.1	82
1984	50.1	11.1	4.9	5.8	21.8	99
1985	49.1	11.5	4.7	5.6	21.7	98
1986	44.1	10.4	4.2	5.1	19.7	89
1987	43.0	10.2	4.0	4.8	19.1	86
1988	44.2	10.5	4.1	4.9	19.5	88

1/ Includes Puerto Rico. Detailed State data shown in appendix table 2. 2/ Fertilizer use estimates for 1977 to 1984 are based on USDA data, while 1985 through 1988 are TVA estimates. 3/ Totals may not add due to rounding.

Source: (3).

Table 8.--Regional plant nutrient consumption for year ending June 30 1/

Region	1987	1988	Annual change
	1,000 tons		Percent
Northeast	747	660	-12
Lake States	2,469	2,410	-2
Corn Belt	6,164	6,420	4
Northern Plains	2,266	2,344	3
Appalachia	1,489	1,489	0
Southeast	1,488	1,427	-4
Delta States	827	846	2
Southern Plains	1,460	1,669	14
Mountain	835	857	3
Pacific 2/	1,278	1,378	8
U.S. total 3/	19,023	19,499	2.5

1/ Includes N, P2O5, and K2O. Totals may not add due to rounding. 2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 2.

Source: (3).

fell only in the Northeast and Southeast, while potash use declined in the Northeast and Lake States.

The proportion of fertilizers applied as single nutrient materials gained an increasing share of the market, constituting 59 percent of U.S. fertilizer use in 1987/88, as farmers continued to shift toward the use of more concentrated materials to meet plant nutrient needs (table 10).

Increases in crop prices received by farmers, while offset somewhat by higher fertilizer prices, apparently led to increased fertilizer use on corn, soybeans, and wheat in 1988 (table 11).

Corn for Grain

Fertilizer was applied to 97 percent of the corn acres in 1987/88 as the proportion of acres fertilized with each of the three nutrients rose. Application rates of nitrogen and phosphate also increased from a year earlier to 137 and 63 pounds, respectively, while the rate for potash remained at 85 pounds.

Table 9.--Regional plant nutrient use for year ending June 30 1/

Region	1987	1988	Annual change
	1,000 tons		Percent
Nitrogen:			
Northeast	290	264	-9
Lake States	1,063	1,053	-1
Corn Belt	2,889	2,991	4
Northern Plains	1,698	1,737	2
Appalachia	603	598	-1
Southeast	665	614	-8
Delta States	511	494	-3
Southern Plains	1,022	1,204	18
Mountain	573	583	2
Pacific 2/	882	925	5
U.S. total 3/	10,196	10,462	2.6
Phosphate:			
Northeast	203	174	-15
Lake States	493	505	2
Corn Belt	1,255	1,303	4
Northern Plains	468	486	4
Appalachia	378	378	0
Southeast	300	281	-6
Delta States	132	146	11
Southern Plains	305	324	6
Mountain	218	228	5
Pacific 2/	250	282	12
U.S. total 3/	4,003	4,106	2.6
Potash:			
Northeast	253	222	-12
Lake States	912	852	-7
Corn Belt	2,020	2,126	5
Northern Plains	100	121	22
Appalachia	508	513	1
Southeast	524	532	2
Delta States	184	206	12
Southern Plains	133	140	5
Mountain	44	46	5
Pacific 2/	146	171	17
U.S. total 3/	4,824	4,931	2.2

1/ Totals may not add due to rounding. 2/ Includes Alaska and Hawaii. 3/ Excludes Puerto Rico. Detailed State data shown in appendix table 3.

Source: (3).

Cotton

About 80 percent of cotton acreage received some fertilizer in 1987/88, up from a year earlier, as the proportion of acres fertilized with nitrogen and phosphate increased. Applica-

Table 10.--Average annual U.S. fertilizer use 1/

Year ending June 30 4/	Multiple nutrient 2/ Quantity	Multiple nutrient 2/ Share of total	Single nutrient 3/ Quantity	Single nutrient 3/ Share of total
	Million tons	Percent	Million tons	Percent
1979	23.7	46	27.7	54
1980	23.3	44	29.5	56
1981	23.5	44	30.5	56
1982	20.9	43	27.8	57
1983	18.4	44	23.5	56
1984	21.2	42	28.9	58
1985	20.6	44	26.7	56
1986	17.8	42	24.7	58
1987	17.1	42	24.1	58
1988	17.5	41	24.9	59

1/ Includes Puerto Rico. 2/ Fertilizer materials that contain more than one primary nutrient. 3/ Materials that contain a single nutrient. 4/ Fertilizer use estimates for 1979 to 1984 are based on USDA data, while 1985 through 1988 are TVA estimates.

Source: (3).

tion rates, however, declined for all three nutrients, leading to mixed results in average nutrient use on cotton.

Soybeans

Some fertilizer was applied to 32 percent of soybean acres in 1987/88 as both the proportion of acres fertilized and application rates rose for all three nutrients. Application rates were highest for potash at 79 pounds, followed by phosphate at 48 pounds, and nitrogen at 22 pounds.

Wheat

The share of wheat acres fertilized rose to 83 percent, showing a gain for the sixth consecutive year. The shares receiving nitrogen and phosphate increased to 83 and 53 percent, respectively, while the share receiving potash rose from 15 to 18 percent. Nitrogen and phosphate application rates also went up by 2 pounds per acre, while potash application rates jumped to 52 pounds per acre, an increase of 9 pounds.

World Fertilizer Review and Prospects

World plant nutrient production and use increased in 1986/87 and is projected to have also expanded in 1987/88. Fertilizer production and consumption rose slightly in the developed market economies, but increased to a greater extent in the developing market economies.

Supplies

World plant nutrient supplies in 1986/87 increased almost 4 percent to 134.9 million metric tons (table 12). Nitrogen supplies rose 4 percent to 73.5 million tons, while phosphate supplies grew 5 percent to 35.0 million metric tons. Potash supplies increased to 26.4 million metric tons (about 2 percent). Due to greater production, world plant nutrient supplies likely rose almost 7 percent in 1987/88 with all three plant nutrients exhibiting an increase.

U.S. planted acreage in 1989 will likely increase because less acreage will have to be taken out of production to par-

Table 11.--Fertilizer use on selected U.S. field crops 1/

Crop, year	Acres receiving: Any fertilizer	Acres receiving: N	Acres receiving: P2O5	Acres receiving: K2O	Application rates: N	Application rates: P2O5	Application rates: K2O
	Percent				Pounds per acre		
Corn for grain:							
1984	97	97	87	82	138	65	87
1985	98	97	86	79	140	60	84
1986	96	95	84	76	132	61	80
1987	96	96	83	75	132	61	85
1988	97	97	87	78	137	63	85
Cotton:							
1984	77	76	48	32	81	48	53
1985	76	76	50	34	80	46	52
1986	80	80	50	39	77	44	50
1987	76	76	47	33	82	44	45
1988	80	80	54	32	78	42	39
Soybeans:							
1984	34	20	30	32	17	46	72
1985	32	17	28	30	15	43	72
1986	33	18	29	31	15	43	71
1987	30	15	25	28	20	47	75
1988	32	16	26	31	22	48	79
All wheat:							
1984	76	76	49	17	62	37	46
1985	77	77	48	16	60	35	36
1986	79	79	48	19	60	36	44
1987	80	80	50	15	62	35	43
1988	83	83	53	18	64	37	52

1/ Detail for selected States by crop are found in appendix tables 3 through 6.

Table 12.--World plant nutrient supply and consumption for years ending June 30

Plant nutrient	1986	1987	1988 1/
	Million metric tons		
Available supply: 2/			
Nitrogen	71.0	73.5	75.1
Phosphate	33.3	35.0	38.8
Potash	25.9	26.4	29.8
Total 3/	130.0	134.9	143.7
Consumption:			
Nitrogen	70.0	72.4	73.8
Phosphate	33.2	34.7	35.8
Potash	25.6	26.1	26.5
Total 3/	128.8	133.2	136.1

1/ Projected. 2/ Production less industrial uses and losses in transportation, storage, and handling. 3/ Totals may not add due to rounding.

Source: (4, 5).

ticipate in Government programs for wheat and feed grains. Commodity prices will be higher, reflecting the effects of the 1988 drought on commodity stocks, and should also encourage increased plantings. In addition, planted acreage outside the United States will probably expand, resulting in an increase in non-U.S. fertilizer production and consumption.

Consumption

World fertilizer consumption in 1986/87 increased over 3 percent from a year earlier to 133.2 million metric tons (table 12). Nitrogen consumption rose over 3 percent to 72.4 million metric tons, while phosphate consumption increased almost 5 percent to 34.7 million metric tons. Potash consumption grew 2 percent to 26.1 million metric tons.

World plant nutrient use rose an estimated 2 percent in 1987/88, due to greater demand in the developing market economies of Latin America and Asia.

Projections for 1988-93

According to 1988 Food and Agriculture Organization (FAO)/ World Bank forecasts, world nitrogen, phosphate, and potash fertilizer consumption is expected to grow 13, 14, and 11 percent, respectively, during 1988-93 (table 13). Fertilizer production and use are projected to grow fastest in the developing countries and centrally planned economies of Asia.

In developed countries, consumption is expected to increase less than 5 percent by 1993, down from earlier projections of over 10-percent growth. Stable demand in Western Europe will also slow growth in world fertilizer use and affect nitrogen and phosphate production rates. Canadian potash exports are expected to increase; however, Eastern European and Soviet Union potash exports could decline, resulting in a smaller potash production gain in those areas.

Table 13.--Projected 1988-93 change in world fertilizer supply and consumption 1/

World regions	Nitrogen	Phosphate	Potash
	Percent increase		
Supply potential:			
Developed market economies	1	6	2
Developing market economies	27	16	25
Eastern Europe and the Soviet Union	8	11	9
Centrally planned countries of Asia	8	9	134
Total	10	10	5
Consumption:			
Developed market economies	0	5	5
Developing market economies	26	24	28
Eastern Europe and the Soviet Union	16	13	6
Centrally planned countries of Asia	15	18	47
Total	13	14	11

1/ Detail in appendix table 7.

Source: (4, 5).

Nitrogen and phosphate production in the developed countries is expected to grow 1 and 6 percent, respectively, while potash production is projected to be up 2 percent. Most of this increase will come from greater Canadian potash and nitrogen production. Israel is also expected to expand potash production. Higher phosphate fertilizer production in the United States will depend heavily on phosphate export potential.

In the developing countries, the supply potential of the three plant nutrients will be increased from 16 to 27 percent by 1993, while consumption will be up 24 to 28 percent. The rapid increase in consumption can be attributed to the goals of many developing countries to move toward self-sufficiency in food and fertilizer production.

The availability of nitrogen production capacity relative to projected demand will likely ensure adequate supplies until the end of the decade. However, excess production capacity will be reduced, indicating that supplies will not meets demand without price increases.

Africa, Asia, and Western Europe are projected to be nitrogen-deficit areas through 1993. Eastern Europe, Latin America, the Near East, and the Soviet Union will have surpluses because countries with plentiful natural gas resources produce nitrogen fertilizer for export.

Among Asian and Eastern European centrally planned countries, greater nitrogen production capacity will be limited mostly to those plants built in China. France, the Netherlands, and the United Kingdom are expected to expand nitrogen production.

Ammonia plants are scheduled to be completed during the next few years in Trinidad-Tobago, the United Kingdom, and Belgium. New ammonia-urea complexes are scheduled to be built in Iraq, Saudi Arabia, Indonesia, Bangladesh, India, Pakistan, and China. Nitrogen production will likely expand near natural gas reserves in the developing countries of India, Indonesia, Saudi Arabia, Mexico, and Trinidad-Tobago.

World phosphate fertilizer production will center primarily in the United States, the Soviet Union, and Morocco during 1988-93. About one-third of the phosphoric acid supply capability will be located in the United States. The Soviet Union and Morocco will have 20 and 10 percent, respectively. Increased phosphate production in India, China, Mexico, Tunisia, and Brazil will also add to world supplies.

The developed countries and Africa are projected to have surpluses of phosphate fertilizer. Conversely, the Soviet Union, Asia, and Eastern Europe will be deficit areas. Asia is expected to be the greatest deficit area.

On a world basis, phosphate rock capacity will be more than adequate to meet demand; the main phosphate surplus areas are North America and Africa. Many projects are planned for the development of indigenous phosphate resources in China, Jordan, Brazil, Mexico, India, and Morocco. However, many of these countries will remain significant importers of processed phosphates through the early 1990's, since the development of new phosphate mines can take a long time, and phosphate rock processing facilities have not been fully developed. The Soviet Union and India are projected to be the world's largest importers of phosphoric acid, accounting for an estimated 45 percent of world trade.

The 1988 FAO/World Bank forecast indicates surplus potash capacity through 1993, with most of the surplus in Canada. Jordan may show a small capacity expansion. In contrast, virtually no change in capacity is foreseen in Western Europe. The Soviet Union may experience no change in production capability through 1993, since one mine was recently flooded and abandoned, while another experienced production problems. The development of potash production capability in Brazil and China has been progressing satisfactorily. No significant development is expected for the next few years in Chile, the Congo, Ethiopia, Thailand, or Tunisia.

Table 14.--Projected regional shares of world fertilizer supply potential and consumption 1/

World regions	Nitrogen		Phosphate		Potash	
	1988	1993	1988	1993	1988	1993
	Percent					
Supply potential:						
Developed market economies	28.6	26.3	45.1	43.4	55.1	53.2
North America	14.6	13.4	23.8	23.9	33.8	32.4
Western Europe	12.9	12.0	12.7	11.6	17.3	16.6
Oceania	0.4	0.5	3.9	3.8	0.0	0.0
Other countries	0.6	0.4	4.7	4.2	4.0	4.2
Developing market economies	22.8	26.2	21.8	23.1	2.2	2.6
Africa	0.6	0.8	9.4	9.8	0.0	0.0
Latin America	5.4	6.0	4.9	5.2	0.0	0.2
Asia	16.8	19.4	7.5	8.1	2.2	2.4
Eastern Europe and the Soviet Union	30.7	30.0	25.0	25.3	42.5	43.9
Centrally planned countries of Asia	17.9	17.5	8.1	8.1	0.1	0.2
Consumption:						
Developed market economies	31.8	28.0	32.0	29.6	42.5	40.2
North America	14.7	13.3	12.1	11.3	18.3	18.0
Western Europe	15.0	12.7	14.0	12.3	20.5	18.5
Oceania	0.5	0.6	3.0	3.0	0.9	1.0
Other countries	1.5	1.4	3.0	3.0	2.9	2.7
Developing market economies	24.6	27.4	25.5	27.9	16.0	18.4
Africa	1.2	1.4	1.9	2.1	1.2	1.4
Latin America	5.3	5.6	7.8	7.9	7.2	7.9
Asia	18.0	20.4	15.8	17.9	7.6	9.1
Eastern Europe and the Soviet Union	22.1	22.7	31.9	31.5	37.4	35.9
Centrally planned countries of Asia	21.5	21.9	10.6	11.0	4.1	5.5

1/ Forecasts for year ending June 30.

Source: (4).

World potash production potential is expected to increase about 5 percent. Canada will add the most capacity, with Israel, Jordan, Brazil, Thailand, and China also making additions. Projected regional shares of world fertilizer supply and demand indicate production and use will continue to shift away from the developed countries toward the developing countries. The centrally planned countries' share of world fertilizer production will remain relatively constant at about 43 percent through 1993. Their share of nutrient consumption will stay about the same at 36 percent (table 14).

Potash supply capability should be adequate into the next decade. Increased Canadian production should provide North America with the greatest potash surplus. Eastern Europe and the Soviet Union will also remain major surplus areas. Western Europe, Asia, Africa, and Latin America are projected to be deficit areas.

World Trade Developments

Existing nitrogen trade patterns should continue. The Soviet Union will likely continue to supply nitrogen fertilizer to the United States, Western Europe, and Asia. Additional nitrogen fertilizer production in Trinidad-Tobago will compete for a share of the already crowded North American, Western European, and Mediterranean markets. Surplus nitrogen from the Near East will probably move to the Asian markets.

Phosphate production is projected to grow in most regions of the world. World consumption will increase at a faster rate than production, causing the supply-demand balance to tighten. Asia should have the most active trade because the countries in this region are expected to produce only a small share of the phosphate they need. The African and U.S. phosphate fertilizer industries will compete for this growing market.

Canada, East Germany, Israel, and the Soviet Union are the major potash exporters. Canada's exports are expected to increase relative to the other major exporters because it will further penetrate the large Indian and Chinese markets and continue its exports to the United States.

World Fertilizer Prices

World fertilizer nutrient consumption rose in 1987/88 by about 2 percent, while available supply increased over 6 percent. However, a tightening of world supplies is expected during fertilizer year 1988/89 because demand could jump 5 percent. This heightened demand, coupled with the inadequate supply increase, will push world prices upward. Fertilizer prices for most products rose during the 1987/88 fertilizer year and have continued this trend during the first part of 1988/89. The long-awaited resumption of demand from China and the strong import demand of the United States have greatly contributed to recent upward price trends.

References

1. Agriculture Canada. "Market Commentary: Farm Inputs and Finance." December 1988.

2. Potash/Phosphate Institute. Selected reports. Atlanta, Georgia.

3. Tennessee Valley Authority, Economics and Marketing Staff. *Commercial Fertilizer Consumption*. December 1988.

4. United Nations, Food and Agriculture Organization. *Current World Fertilizer Situation and Outlook, 1986/87 to 1992/93*. Rome, 1988.

5. __________. *1987 Fertilizer Yearbook*. Rome, 1988.

6. U.S. Department of Commerce, Bureau of the Census. *U.S. Exports, Commodity and Country*. FT-410. November 1988 and earlier issues.

7. __________. *U.S. Imports, Commodity and Country*. FT-135. November 1988 and earlier issues.

8. __________. *Inorganic Fertilizer Materials and Related Products*. M28-B. November 1988 and earlier issues.

PESTICIDES

Demand

Agricultural pesticide use in 1989 is expected to be up 7 percent from a year earlier. Planted acreage for corn, wheat, and soybeans will likely rise; cotton and rice will probably decline.

Table 15.--Estimated pesticide demand by U.S. field crop farmers

Crops	Projected 1989 use		
	Herbicides	Insecticides	Fungicides
	Million pounds (active ingredients)		
Row:			
Corn	225	27.9	.06
Cotton	16	15.1	.16
Grain sorghum	11	1.7	0.00
Peanuts	6	1.3	6.12
Soybeans	109	9.5	.06
Tobacco	1	2.4	.31
Total	368	57.9	6.71
Small grains:			
Barley and oats	6	.2	0.00
Rice	12	.5	.07
Wheat	16	2.1	.87
Total	34	2.8	.94
Total	402	60.7	7.65
1988 total	372	59.7	7.56

Pesticide use on major field crops is projected at 470 million pounds active ingredients (a.i.) in 1989 (table 15). Herbicides account for 86 percent of the total pesticide use, while insecticides make up 13 percent. The 30-million-pound a.i. rise in herbicide use in 1989 can largely be attributed to the increase in corn acreage, which could exceed year-earlier levels by 9 to 15 percent. Corn and soybeans account for 56 percent and 27 percent of the total herbicide use, respectively.

Insecticide and fungicide use in 1989 is expected to equal that of a year earlier. Although corn insecticide use will probably go up, it will be offset by a decline in cotton insecticide use. Fungicides are most commonly used in peanut production.

Supplies

The domestic supply of pesticides available for U.S. farm use is expected to be down 1 percent from last year but adequate to meet 1989 crop needs (table 16). Production is expected to be up 7 percent and inventory carryover down 22 percent. The increase in exports can be attributed in part to the continued low value of the dollar relative to other currencies.

Table 16.--U.S. pesticide production, inventories, exports, and domestic availability

Item	Quantity (active ingredients) 1/ 1988	Projected 1989	Change 88-89
	Million pounds		Percent
Herbicides:			
Production	475	524	10
Carryover	177	139	-21
Imports 2/	57	67	18
Exports 2/	158	167	6
Domestic availability	551	563	2
Insecticides:			
Production	222	222	0
Carryover	52	39	-25
Imports 2/	12	13	8
Exports 2/	61	72	18
Domestic availability	225	202	-10
Fungicides:			
Production	54	58	7
Carryover	7	6	-14
Imports 2/	5	3	-40
Exports 2/	25	23	-8
Domestic availability	41	44	7
All pesticides:			
Production	751	804	7
Carryover	236	184	-22
Imports 2/	74	83	12
Exports 2/	244	262	7
Domestic availability	817	809	-1

1/ The responding firms produce a major portion of all U.S. farm pesticides. 2/ Does not include imports or exports by pesticide formulators.

Source: USDA survey of basic pesticide manufacturers, December 1988.

Domestic herbicide supplies for 1989 are projected at 563 million pounds a.i., up 2 percent from last year. Manufacturers are expected to increase production by 10 percent, and during the past year inventories have been decreased by 21 percent. Herbicide exports by pesticide manufacturers are expected to be up 6 percent, while imports may be up 18 percent.

Insecticide supplies are expected to be down 10 percent in 1989. Insecticide production is expected to be stable, but inventory carryover may be down 25 percent from 1988 levels. Insecticide exports are likely to be up in 1989. Fungicide supplies are projected to be up 7 percent primarily due to increased production.

Overall domestic plant capacity use is projected at 81 percent for 1989, up 6 percentage points from 1988 (table 17). Manufacturers are increasing production, especially for herbicides, to meet domestic needs arising from increased planted acreage and continued expansion of exports.

Prices

Pesticide prices quoted by manufacturers for the 1989 crop season are projected to be up 2 to 5 percent from last year (table 18). During the early 1980's, aggregate pesticide prices at the retail level declined, bottoming out in 1986 and 1987. Between 1987 and 1988, aggregate herbicide prices

Table 17.--U.S. pesticide production capacity utilization rates

Year	Herbicides	Insecticides	Fungicides	All pesticides
	Percent			
1980	77	79	84	78
1981	74	72	68	73
1982	84	68	70	80
1983	66	33	71	54
1984	67	29	73	52
1985	62	56	66	61
1986	64	63	61	65
1987	63	61	59	62
1988	75	76	59	75
1989 1/	82	76	63	81

1/ Projected.

Source: USDA annual survey of basic pesticide manufacturers, December 1988.

Table 18.--Pesticide price changes

Item	1986/87 1/	1987/88 1/	Projected 1988/89 2/
	Percent		
Herbicides	*	4	5
Insecticides	*	3	4
Fungicides	na	na	2

* = Less than 1 percent. na = Not available.

1/ April prices paid by farmers. 2/ Quoted manufacturer prices.

Source: USDA annual survey of basic pesticide producers, December 1988.

increased from $4.05 per pound a.i. to $4.20, while insecticide prices increased from $10.25 to $10.57.

1988 Pesticide Use

Corn for Grain

Herbicides were used on 96 percent of the surveyed corn acreage in 1988, similar to the previous 2 years (table 19). South Dakota farmers treated the fewest acres for weed control at 82 percent.

Insecticides were used on 35 percent of the corn acreage in 1988, down from 41 percent in the 2 previous years. Insecticide use was greatest in Nebraska, where 55 percent of the corn acreage was treated. In contrast, Minnesota and South Dakota farmers treated only 20 and 19 percent of their corn acreage, respectively. In Nebraska, corn rootworm larvae can be a problem because about two-thirds of the corn acreage is irrigated and a high proportion is planted to corn every year. In Minnesota and South Dakota, more of the corn acreage is rotated with other crops, including small grains, thus reducing corn rootworm problems.

Table 19.--Pesticide use on selected row crops, 1988 1/

Crop, State	Acres treated with: Herbicides	Insecticides
	Percent	
Corn:		
Illinois	99	39
Indiana	97	34
Iowa	100	29
Michigan	98	40
Minnesota	97	20
Missouri	98	28
Nebraska	95	55
Ohio	98	40
South Dakota	82	19
Wisconsin	92	43
1988 average	96	35
1987 average	96	41
1986 average	96	41
Soybeans:		
Arkansas	92	nr
Georgia	93	4
Illinois	99	30
Indiana	98	12
Iowa	99	4
Kentucky	93	1
Louisiana	92	2
Minnesota	100	2
Mississippi	95	nr
Missouri	92	nr
Nebraska	97	1
North Carolina	88	4
Ohio	94	4
Tennessee	93	nr
1988 average	96	8
1987 average	95	3
1986 average	96	4
Cotton:		
Arizona	99	65
Arkansas	100	75
California	86	83
Louisiana	98	85
Mississippi	99	95
Texas	95	51
1988 average	95	66
1987 average	94	61

nr = None reported

1/ States planted 53.2 million acres of corn (79 percent of U.S. total), 48.8 million acres of soybeans (83 percent of U.S. total), and 9.7 million acres of cotton (81 percent of U.S. total) in 1988.

Table 20.--Percent of corn acres treated with herbicides by number of treatments, 1988

State	Number of treatments: 1	2	3	Average acre-treatments
	Percent			Number
Illinois	74	25	1	1.28
Indiana	87	13	nr	1.13
Iowa	53	42	4	1.51
Michigan	80	17	2	1.22
Minnesota	47	49	4	1.57
Missouri	91	9	nr	1.09
Nebraska	87	12	1	1.13
Ohio	75	25	nr	1.25
South Dakota	82	18	1	1.39
Wisconsin	82	18	1	1.19
Area	70	28	2	1.31

nr = None reported.

In the 10 surveyed States, an average of 1.3 herbicide treatments per acre were made to control weeds (table 20). Of the 51 million acres of corn treated, 70 percent were treated once and 28 percent twice. Minnesota, with 49 percent, and Iowa, with 42 percent, had the highest proportion of corn acreage treated twice.

Atrazine + alachlor was the most commonly used herbicide treatment: it was applied to 17 percent of the treated acreage (table 21). Both active ingredients control a large number of broadleaf and grass weeds, but when applied in combination, the control spectrum is broadened. Atrazine + metolachlor and atrazine and alachlor alone were also widely applied throughout the area.

EPTC was used on 21 percent of the treated area in both Minnesota and South Dakota. EPTC controls many annual grasses, especially wild proso millet, a major problem in the northern Corn Belt. It is also more biologically active at low soil temperatures than many other preplant herbicide materials.

Iowa, Minnesota, and South Dakota treated more of their corn acreage with dicamba, 2,4-D, or a tank-mix of dicamba + 2,4-D. These materials are applied postemergence for broadleaf weed control.

Insecticides were generally applied at planting for corn rootworm larvae control. However, insecticides were also used

Table 21.--Selected herbicides and insecticides used in corn production, 1988

Item	IL	IN	IA	MI	MN	MO	NE	OH	SD	WI	Area
						1,000					
Acres treated with herbicides	9771	5025	11248	2052	5546	2163	6536	3220	2580	3160	51301
Acre-treatments by active ingredients:						Percent					
Single materials--											
Alachlor	8	2	14	5	22	1	8	6	19	8	10
Atrazine	10	12	7	19	7	18	21	10	11	17	12
Bromoxynil	1	1	6	1	8	2	1	2	2	4	3
Cyanazine	nr	3	3	1	6	1	4	4	2	8	3
Dicamba	5	2	9	2	14	2	3	9	21	nr	7
EPTC	2	nr	6	nr	21	3	2	1	21	3	6
Metolachlor	7	2	16	nr	12	3	1	4	6	3	7
2,4-D	7	5	12	2	11	2	5	6	12	1	7
Other	4	2	6	6	5	nr	2	1	8	6	4
Tank mixes--											
Atrazine + alachlor	19	26	12	31	7	21	21	18	4	21	17
Atrazine + butylate	7	7	nr	nr	nr	9	4	2	nr	2	3
Atrazine + cyanazine	12	6	12	8	2	21	8	8	1	5	9
Atrazine + metolachlor	18	19	7	20	3	10	12	25	3	9	12
Atrazine + others	10	5	16	7	8	4	4	6	9	4	9
Alachlor + cyanazine	2	2	1	1	3	1	1	2	nr	10	2
Dicamba + 2,4-D	4	1	8	nr	8	nr	2	4	7	nr	4
Other 2-way mixes	2	2	7	5	15	1	2	2	4	10	5
3-way mixes	9	17	10	14	7	12	12	15	7	9	11
Total	128	113	151	122	157	109	113	125	139	119	131
						1,000					
Acres treated with insecticides	3831	1811	3317	835	1140	629	3799	1252	597	1501	18712
Acre-treatments by active ingredient:						Percent					
Single materials--											
Carbofuran	3	5	11	17	8	6	9	12	5	5	8
Chlorpyrifos	34	23	42	40	14	48	30	27	9	13	30
Fonofos	12	20	13	20	5	nr	7	23	41	9	13
Phorate	4	5	6	11	24	nr	4	3	14	23	8
Terbufos	32	18	22	9	46	6	44	29	27	46	31
Other	14	31	6	6	3	42	17	9	5	4	13
Total	101	102	100	103	100	103	111	103	100	100	103

nr = None reported.

to control cutworms and European corn borers. Terbufos (31 percent) and chlorpyrifos (30 percent) were the most commonly used insecticides.

Soybeans

In 1988, 96 percent of the soybean acreage in the surveyed States was treated with herbicides (table 19). Insecticides were used on 8 percent of the soybean acreage in 1988, double the amount for the 2 previous years. Illinois and Indiana farmers treated 30 and 12 percent, respectively, of their soybean acreage, primarily for spider mite control. Spider mite infestations developed in July and spread throughout the Midwest. Iowa had a severe spider mite infestation in August 1988. The data presented here were collected in the latter part of July and do not reflect insecticide treatments made by farmers to control these infestations.

Herbicide data for soybeans are divided into the northern and southern producing regions. Because of differences in growing conditions and weed problems, the herbicide materials used and number of applications vary in the two regions.

In the northern soybean region, farmers applied 1.4 treatments per acre, compared to 1.6 treatments per acre in the southern region (table 22). In the northern region, Min-

Table 22.--Percent of soybeans acres treated with herbicides by number of treatments, 1988

Region, State	Number of treatments 1	2	3	4	Average acre-treatments
	Percent				Number
Northern:					
Illinois	59	36	4	nr	1.45
Indiana	79	18	3	nr	1.24
Iowa	65	29	6	nr	1.42
Minnesota	50	42	6	2	1.59
Missouri	61	37	2	nr	1.42
Nebraska	79	18	3	nr	1.24
Ohio	81	19	nr	nr	1.19
Area	65	30	4	*	1.39
Southern:					
Arkansas	63	31	4	3	1.46
Georgia	46	45	9	nr	1.63
Kentucky	63	30	6	1	1.45
Louisiana	55	35	8	2	1.56
Mississippi	44	35	15	5	1.81
North Carolina	74	20	6	nr	1.32
Tennessee	29	53	16	1	1.89
Area	54	35	9	2	1.59

nr = None reported. * = Less than 1 percent.

nesota had the highest number of treatments per acre (1.6); in the southern region, North Carolina had the fewest (1.3). In Minnesota, farmers typically use a preemergence herbicide and follow it with a postemergence application if broadleaf weed problems arise. In North Carolina a large proportion of the soybean acreage is double cropped with winter wheat. Because the soybeans are planted directly into the wheat stubble, less soil is disturbed. In addition, a leaf canopy is rapidly established, shading the ground and thereby inhibiting weed seed germination. In the south, 9 percent of the treated acreage received 3 applications; Mississippi, with 15 percent, and Tennessee, with 16 percent, had the highest proportion.

In the northern soybean region, trifluralin applied alone or tank-mixed with other herbicides was the most commonly used material (table 23). Applied preplant incorporated, it controls many broadleaf and grass weeds. Bentazon was second in importance; it is applied postemergence for broadleaf weed control. Farmers in the region used several tank-mix treatments, none of which was clearly dominant. However, of the eight tank mixes listed, metribuzin or trifluralin were included in three. Metribuzin is added for cocklebur and velvetleaf control.

In the southern soybean region, trifluralin alone (29 percent) or tank-mixed with imazaquin (8 percent) or metribuzin (5 percent) was the most common herbicide material used in 1988 (table 24). Imazaquin, registered in 1986, was the second most common material. Imazaquin can be applied preplant, preemergence, or postemergence. Chlorimuron-ethyl, also registered in 1986, ranked third in importance. It is applied postemergence and controls many broadleaf weeds, including morningglories and cockleburs up to 12 inches in height.

Acifluorfen + bentazon was used on 9 percent of the treated acreage in the south. Acifluorfen controls a large number of broadleaf weeds, and bentazon is added to the mixture to control cocklebur and prickly sida.

Cotton

Herbicides were used on 95 percent of the cotton acreage in the surveyed States in 1988 (table 19). Insecticides were used on 66 percent of the cotton acreage, ranging from 95 percent in Mississippi to 51 percent in Texas. Most of the cotton in Texas is grown in the High Plains, where insect pressure is low.

On average, cotton farmers applied 1.8 herbicide treatments per acre in 1988. Treatment frequency ranged from 3.3 in Mississippi to 1.3 in California and Texas (table 25). The severe weed pressure in the Delta is demonstrated by the large proportion of the cotton acreage receiving 3 or more herbicide treatments per season. In Texas and the irrigated West, 1 or 2 herbicide treatments per acre are the norm.

Trifluralin alone (57 percent) was the most commonly used herbicide on cotton, followed by pendimethalin (21 percent) (table 26). Fluometuron was used extensively in the Delta,

Table 23.--Selected herbicides used in northern soybean production, 1988

Item	IL	IN	IA	MN	MO	NE	OH	Area
				1,000				
Acres treated with herbicides	8704	4219	7899	4900	3942	2338	3652	35654
				Percent				
Acre-treatments by active ingredients:								
Single materials--								
Alachlor	3	8	4	6	5	nr	4	4
Bentazon	21	11	14	26	6	8	7	15
Chloramben	2	nr	5	7	1	nr	4	3
Chlorimuron-ethyl	7	2	6	nr	22	1	3	6
Ethalfluralin	5	2	2	7	2	4	nr	3
Imazaquin	5	3	1	3	5	3	2	3
Metolachlor	6	3	1	1	2	1	2	3
Metribuzin	1	5	4	1	6	5	3	3
Sethoxydim	5	1	4	12	1	nr	1	4
Trifluralin	20	5	29	34	15	11	nr	19
Other	10	9	9	14	8	17	6	10
Tank mixes--								
Trifluralin + dimethazone	3	nr	10	nr	nr	8	nr	3
Trifluralin + imazaquin	7	6	7	nr	13	8	2	6
Trifluralin + metribuzin	7	6	11	13	9	8	3	8
Aciflurofen + bentazon	6	3	1	10	nr	nr	3	4
Alachlor + linuron	2	10	2	2	6	3	8	4
Alachlor + metribuzin	1	13	3	4	3	3	14	5
Metolachlor + metribuzin	2	8	2	nr	1	1	12	3
Pendimethalin + imazaquin	10	7	6	nr	11	11	4	7
Other 2-way mixes	17	22	17	17	19	18	34	20
3-way mixes	8	3	5	3	8	14	7	6
Total	145	124	142	159	142	124	119	139

nr = None reported.

Table 24.--Selected herbicides used in southern soybean production, 1988

Item	AR	GA	KY	LA	MS	NC	TN	Area
				1,000				
Acres treated with herbicides	2984	834	916	1653	2285	1286	1308	11266
Acre-treatments by active ingredients:				Percent				
Single materials--								
Alachlor	5	3	6	5	nr	12	nr	4
Bentazon	5	5	3	nr	5	1	6	4
Chlorimuron-ethyl	7	29	3	10	9	5	13	10
Fluazifop-butyl	3	nr	16	7	2	5	15	6
Glyphosate	1	4	5	3	1	11	2	3
Imazaquin	13	nr	5	13	14	5	25	12
Metribuzin	5	18	nr	5	16	2	4	7
Pendimethalin	4	18	nr	3	15	4	6	7
Trifluralin	39	14	19	14	43	6	36	29
Other	18	11	20	22	13	15	11	16
Tank mixes--								
Aciflurofen + bentazon	7	nr	5	6	15	4	21	9
Pendimethalin + imazaquin	6	3	5	8	6	11	6	7
Trifluralin + imazaquin	9	8	14	3	7	6	11	8
Trifluralin + metribuzin	5	13	1	2	9	2	2	5
Other 2-way mixes	13	25	23	45	16	33	26	24
3-way mixes	4	12	21	12	8	11	6	9
Total	146	163	145	156	181	132	189	159

nr = None reported.

Table 25.--Percent of cotton acres treated with herbicides by number of treatments, 1988

State	Number of treatments 1	2	3	4	5	6	7	Average acre-treatments
	Percent							Number
Arizona	64	33	4	nr	nr	nr	nr	1.40
Arkansas	11	22	41	15	7	3	1	2.99
California	80	13	5	1	1	nr	nr	1.27
Louisiana	10	35	13	21	12	9	nr	3.16
Mississippi	8	21	28	19	20	4	nr	3.33
Texas	74	25	1	nr	nr	nr	nr	1.28
Area	56	24	9	5	4	1	*	1.82

nr = None reported. * = Less than 1 percent.

either preemergence or as a postemergence directed spray. With directed sprays, drop nozzles are used to place the herbicide under the leaf canopy in the crop row. Tank-mix herbicide treatments were most important in the Delta. MSMA was included in many of the tank mixes and was applied as a postemergence directed spray.

Wheat

Herbicides were used on 38 percent of the winter wheat acreage in the surveyed States in 1988, equalling the percentage of 1986 but showing a 10-percentage point decrease from 1987 (table 27). In 1987, winterkill thinned the wheat stands, thus necessitating greater herbicide use to control invading weeds and prevent additional yield losses.

In States producing spring wheat and durum, herbicide use ranged from 71 percent in Montana to 97 percent in Minnesota. The spring preparation of the seedbed provides a good medium for both crop and weed seed germination; consequently, herbicides are needed and used more.

Insecticide use was highest in Texas (16 percent) and Colorado (14 percent), where Russian wheat aphids have become a major difficulty. Although grasshoppers were a problem again last year in the Northern Plains, insecticide use was minimal because it was not economical to treat the drought-stunted wheat crop.

Herbicides were used on 12 million acres of winter wheat in 1988, with an average of 1.1 treatments per acre (table 28). Of the single materials, chlorsulfuron (42 percent) and 2,4-D (21 percent) were the two most commonly used herbicides. Chlorsulfuron, registered in 1982 for use on wheat, barley, and oats, controls a number of broadleaf and grass weeds and can be applied either preemergence or postemergence. In contrast, 2,4-D controls only broadleaf weeds and is applied postemergence. Chlorsulfuron has gained in popularity

Table 26.--Selected herbicides used in cotton production, 1988

Item	AZ	AR	CA	LA	MS	TX	Area
				1,000			
Acres treated with herbicides	336	680	1164	684	1223	5147	9243
Acre-treatments by active ingredients:				Percent			
Single materials--							
Cyanazine	11	25	15	10	17	1	8
Fluazifop-butyl	2	8	4	17	5	3	5
Fluometuron	nr	53	2	40	58	2	16
MSMA	nr	11	1	6	6	2	3
Norflurazon	nr	12	nr	1	16	nr	3
Pendimethalin	30	14	33	16	6	23	21
Prometryn	14	14	7	15	7	12	11
Trifluralin	25	19	53	20	26	77	57
Other	8	13	10	40	14	5	10
Tank mixes--							
Cyanazine + MSMA	4	18	nr	14	19	nr	5
Fluometuron + MSMA	nr	21	nr	12	21	nr	5
Fluometuron + norflurazon	nr	15	nr	24	31	nr	7
Pendimethalin + norflurazon	nr	11	nr	nr	16	nr	3
Prometryn + MSMA	2	9	nr	21	23	nr	5
Trifluralin + norflurazon	nr	13	nr	27	33	nr	7
Other 2-way mixes	42	29	3	52	27	4	14
3-way mixes	nr	14	nr	1	8	nr	2
Total	140	299	127	316	333	128	182

nr = None reported.

Table 27.--Pesticide use on wheat, 1988 1/

Crop,State	Acres treated with: Herbicides	Insecticides
	Percent	
Winter wheat:		
Arkansas	19	nr
California	79	6
Colorado	25	14
Idaho	88	1
Illinois	6	2
Indiana	9	nr
Kansas	35	2
Missouri	4	nr
Montana	61	4
Nebraska	25	nr
Ohio	7	nr
Oklahoma	48	6
Oregon	100	5
Texas	23	16
Washington	91	1
1988 average	38	4
1987 average	48	7
1986 average	38	5
Spring wheat:		
Idaho	87	9
Minnesota	97	7
Montana	71	5
North Dakota	80	1
South Dakota	84	nr
1988 average	83	3
1987 average	89	7
1986 average	86	12
Durum wheat:		
North Dakota	94	1
1987 average	95	3
1986 average	98	13

nr = None reported.

1/ States harvested 27.4 million acres of winter wheat (69 percent of U.S. total), 9.8 million acres of spring wheat (95 percent of U.S. total), and 2.5 million acres of durum wheat (85 percent of U.S. total) in 1988.

and by 1987 was used on 27 percent of the herbicide treated winter wheat acreage; in comparison, 35 percent was treated with 2,4-D. Before one concludes that this is a trend, it should be noted that, in areas of low annual rainfall, chlorsulfuron has a soil residual of 2 to 4 years, which restricts crop rotation flexibility. Also, in some areas weeds have exhibited resistance to chlorsulfuron. Therefore, data for additional years is needed to determine how chlorsulfuron fits into the overall weed control program for winter wheat.

In the Pacific Northwest, average herbicide treatments per acre range from 1.45 in Oregon to 1.12 in Washington (table 28). Multiple herbicide treatments are needed in this area because winter annual broadleaf and grass weeds constitute a problem that must be controlled during mild portions of the winter. In addition, more two- and three-material tank mixes are used to broaden the spectrum of weed control.

Herbicides were applied to 8.1 million acres of spring wheat and 2.4 million acres of durum in 1988 (table 29). The most commonly used herbicide on both crops was 2,4-D. Trifluralin for foxtail and triallate for wild oats control (or a tank mix of these materials) were used extensively in durum wheat production in North Dakota. Both materials are generally applied postplant incorporated before the crop or weeds emerge. Durum wheat is grown in the northeast quarter of the State, where wild oats pose a larger problem. Foxtail causes difficulties throughout North Dakota, but trifluralin is more biologically active in the higher rainfall areas of the east. In addition, durum wheat is generally of

Table 28.--Selected herbicides used in winter wheat production, 1988

Item	CA	CO	ID	KS	MT	NE	OK	OR	TX	WA	Area
					1,000						
Acres treated with herbicides	348	590	691	3325	1273	500	2324	660	709	1592	12012
Acre-treatments by active ingredients:					Percent						
Single materials--											
2,4-D	50	40	31	13	28	55	10	23	31	21	21
MCPA	22	nr	3	nr	6	nr	1	6	nr	3	2
Chlorsulfuron	4	20	9	65	24	9	81	11	40	5	42
Other	14	5	21	2	4	14	nr	37	10	8	7
Tank mixes--											
2,4-D + chlorsulfuron	nr	5	nr	[illegible]	4	nr	4	10	1	1	4
2,4-D + dicamba	nr	10	3	7	11	4	nr	2	10	5	5
2,4-D + glyphosate	nr	0	4	2	2	nr	nr	1	1	6	2
2,4-D + metsulfuron	nr	10	nr	2	5	14	nr	nr	8	nr	2
Chlorsulfuron + metsulfuron	nr	nr	3	nr	nr	nr	nr	8	nr	16	3
Other 2-way mixes	15	10	30	3	16	4	6	16	9	17	10
3-way mixes	nr	nr	16	2	4	nr	nr	31	1	31	[illegible]
Total	107	100	118	104	104	100	103	145	111	112	107

nr = None reported.

Table 29.--Selected herbicide use in spring wheat production, 1987

Item	Spring wheat						Durum
	ID	MN	MT	ND	SD	Area	ND
				1,000			
Acres treated with herbicides	331	1944	1071	3662	1089	8097	2358
Acre-treatments by active ingredients:				Percent			
Single materials--							
2,4-D	55	13	29	41	35	33	37
MCPA	2	17	2	21	3	14	15
Chlorsulfuron	0	0	13	1	13	4	3
Diclofop-methyl	6	17	0	9	nr	5	5
Triallate	2	6	2	6	nr	4	9
Trifluralin	nr	3	nr	7	nr	4	27
Other	19	10	2	4	10	6	15
Tank mixes--							
2,4-D + chlorsulfuron	nr	nr	20	nr	nr	3	nr
2,4-D + dicamba	11	7	24	5	16	10	10
MCPA + bromoxynil	11	29	nr	2	6	9	3
MCPA + dicamba	nr	4	nr	7	10	6	3
Other	19	17	16	18	13	17	22
Total	126	123	109	122	106	119	150

nr = None reported.

greater value than other spring wheat, so it is economical to apply more herbicide treatments for weed control.

Regulatory Actions

The following is a summary of Special Reviews being conducted by the Environmental Protection Agency (EPA) for pesticides used in agriculture. The public is informed of the initiation of a Special Review with the publication of risk analyses, Position Document (PD) 1. EPA presents its proposed regulatory decision in PD 2/3. After a period of public comment and scientific review, EPA's actual regulatory decision is published in PD 4.

Special Reviews by EPA

Common Name	Category	Major Use	Possible Risk	Status
Aldicarb	Insecticide,	Peanuts, potatoes, nematicide	Acute toxicity cotton, citrus	PD 2/3, FY 89
Amitrole	Herbicide	Noncrop areas	Carcinogen	PD 2/3, FY 89
Captan	Fungicide	Apples, peaches, seed treatment	Tumors, birth defects	PD 4, FY 89
Carbofuran	Insecticide	Corn, peanuts, sorghum, sunflowers	Wildlife, bald eagles	PD 4, FY 89
EBDC's	Fungicides	Apples, potatoes, tomatoes, citrus	Carcinogen, birth defects	PD 2/3, FY 89
Parathion	Insecticide	Wheat, sorghum, fruits	Acute human toxicity	PD 1/2/3, FY 89
Phosdrin	Insecticide	Vegetables, fruits	Acute human toxicity	PD 1, FY 89

SEEDS

Consumption

In 1987/88 crop marketing year, seed use for eight major crops was 5.9 million tons, slightly higher than the previous year, but down 18 percent from 1980/81, when 7.2 million tons of seed were consumed due to record planted acreage. In 1988/89, total seed use is projected to be 6.4 million tons, up 8 percent from the previous year, based on an anticipated 4 to 11 percent jump in planted acres. Wheat, corn, and soybeans will be primarily responsible for this increase, while cotton acreage will probably decline (table 30).

Strong demand for grass seed will continue following the 14.4 million acre Conservation Reserve Program (CRP) signup in 1988. Cumulative CRP enrollment was 2 million acres in 1986, 13.7 million in 1987, and 28.1 million through the seventh signup of 1988. The seventh signup added 2.6 million acres in CRP. Most of the land enrolled so far (90 percent) has been or will be sown to grass. Legislation requires that 12.5 percent of the total enrollment goal (40 million acres) be devoted to trees. Only 6 percent of the enrollment has so far been planted with trees.

Supply

U.S. corn and soybean seed crops were hit hard by the 1988 drought. According to the American Seed Trade Association survey of corn seed companies taken in August, 45 percent of planned seed corn production was destroyed by the drought. To make up for this decline, 32 of the surveyed companies were planning off-season seed corn production. About 70 percent of this production will likely be in the southern United States, and 30 percent in South America. According to industry sources, the off-season production and carryover stock should provide adequate seed corn supplies for domestic use in 1989, if planted acreage doesn't exceed 78 million acres. However, some popular hybrids may be in short supply, requiring farmers to choose other varieties.

Industry sources estimate that drought-reduced soybean seed production will be 40 percent below expectations. However, unlike corn producers, soybean farmers can turn to bin-run seed for supplies.

The curtailment of domestically produced corn and soybean seed will probably affect U.S. trade in these commodities. Exports are likely to be down in 1989, while imports are expected to rise. However, neither exports nor imports of corn

Table 30.--Seed use for U.S. major field crops 1/

Crops	1985/86	1986/87	1987/88	1988/89 2/	Change 87/88 - 88/89
	1,000 tons				Percent
Corn	546	468	482	540	12
Sorghum	48	45	39	42	7
Soybean	1,770	1,653	1,684	1,751	4
Barley	514	430	430	473	10
Oats	614	504	464	436	-6
Wheat	2,790	2,520	2,550	2,933	15
Rice	130	130	159	154	-3
Cotton	92	93	106	87	-18
Total	6,504	5,843	5,914	6,416	8

1/ Crop marketing year. 2/ Projected.

Table 31.--U.S. seed corn exports by volume

Country	1983	1984	1985	1986	1987	January-September 1987	January-September 1988	Change 87-88
	Metric tons							Percent
Canada	2,005	1,292	1,920	1,621	2,505	2,312	2,219	-4
Mexico	27,420	5,153	2,446	3,703	3,143	2,054	2,860	39
Chile	743	1,081	268	64	166	165	531	222
Argentina	3	43	248	867	699	581	1,478	154
France	1,012	1,042	5,266	2,121	2,542	1,365	1,114	-18
Spain	300	723	1,198	1,245	2,049	1,102	2,483	125
Italy	7,218	4,864	12,417	7,939	12,229	6,809	3,341	-51
Greece	1,937	1,512	2,039	3,088	1,894	915	2,200	140
Bulgaria	61	0	0	9,239	0	28	2,717	9604
Turkey	28	279	788	3,224	2,678	2,678	1,104	-59
Japan	1,793	1,260	1,830	720	1,861	865	801	-7
Sub-total	42,520	17,249	28,420	33,831	29,766	18,874	20,848	10
Total exports	50,939	24,097	37,964	44,662	32,412	20,491	22,193	8

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 32.--U.S. seed corn imports by volume

Country	1983	1984	1985	1986	1987	January-September 1987	January-September 1988	Change 87-88
	Metric tons							Percent
Canada	5,531	7,808	9,932	8,102	4,465	3,033	2,309	-24
Chile	0	5,414	1,481	14	67	67	2,055	2967
Hungary	0	608	46	271	196	196	35	-82
Sub-total	5,531	13,830	11,459	8,387	4,728	3,296	4,399	33
Total imports	5,564	17,600	12,573	8,500	4,754	3,322	4,586	38

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 33.--U.S. soybean seed exports by volume

Country	1983	1984	1985	1986	1987	January-September 1987	January-September 1988	Change 87-88
	Metric tons							Percent
Canada	1,995	2,916	1,801	1,510	6,087	6,076	134	-98
Mexico	11,075	29,331	20,114	1,515	12,630	12,616	1,710	-86
France	387	325	535	2,073	1,404	595	1,714	188
Italy	3,784	2,208	8,190	22,522	44,348	24,587	12,846	-48
Turkey	2,527	2,554	5,120	5,879	5,038	5,038	3,798	-25
South Korea	1,001	3,048	500	2	0	0	2,000	na
Japan	1,422	2,764	2,002	2,934	4,151	1,569	293	-81
Sub-total	22,191	43,146	38,262	36,435	73,658	50,481	22,495	-55
Total exports	23,759	50,940	38,747	37,317	75,040	51,749	25,052	-52

na = Not applicable.

Source: Department of Commerce, Bureau of the Census, Foreign Trade Division.

Table 34.--Acres applied for certification for selected grass seeds 1/

Item	1985	1986	1987	1988	Change 87-88
		1,000 acres			Percent
Timothy	58.4	32.1	74.9	100.9	35
All fescue	51.5	56.7	71.7	92.8	29
Tall fescue	26.0	38.8	47.6	54.7	15
Ryegrass	41.9	48.7	59.1	65.3	10
All bromegrasses	9.8	10.8	15.2	21.9	44
Orchardgrass	15.7	14.5	12.8	13.6	6
All wheatgrasses	5.4	9.6	12.9	22.2	72
Other 2/	4.3	4.3	6.2	5.6	-10

1/ U.S. and Canadian acreage. 2/ Other grasses commonly recommended for cover on CRP acres include: switchgrass, bluestems, blue grama, side oats grama, crownvetch, lespedeza, indiangrass, and needlegrass.

and soybean seed typically constitute a large share of total U.S. seed consumption. Over the last 5 years, seed corn exports, as a share of total domestic consumption, have ranged from 5 percent in 1984 to 14 percent in 1983; imports ranged from 1 to slightly over 4 percent in 1984 following the 1983 drought (also a PIK year). Soybean seed exports in 1987 made up about 5 percent of consumption. Data on soybean seed imports are not available.

The countries most affected by a severe falloff in U.S. seed corn exports would likely be the major importing countries: Italy, Mexico, Canada, France, Turkey, Greece, and Japan. While the full effects of the drought on seed corn exports will not be known until later in 1989, two major seed corn export markets, France and Italy, showed declines of 18 and 51 percent, respectively, during the first 9 months of 1988 compared to the corresponding period in 1987 (table 31). These declines can probably be attributed to phytosanitary restrictions the European Community (EC) has imposed on these imports because of their alleged susceptibility to such diseases as stem canker, pod and stem blight, stewart's wilt, and brown stem rot. However, overall seed corn exports for January-September 1988 rose 8 percent by volume.

Seed corn imports prior to spring 1989 planting are expected to supplement the reduced domestic supply. The largest supplier of seed corn has traditionally been Canada, while Chile has exported widely varying amounts. During the first 9 months of 1988, Chile supplied nearly 45 percent of all U.S. seed corn imports, up from only 2 percent during the same period a year earlier. Overall seed corn imports increased almost 40 percent in the first 9 months of 1988 (table 32). Hungary, Romania, and Yugoslavia have been the only other significant foreign sources of seed corn. Most of the foreign off-season seed corn production will likely come from South America.

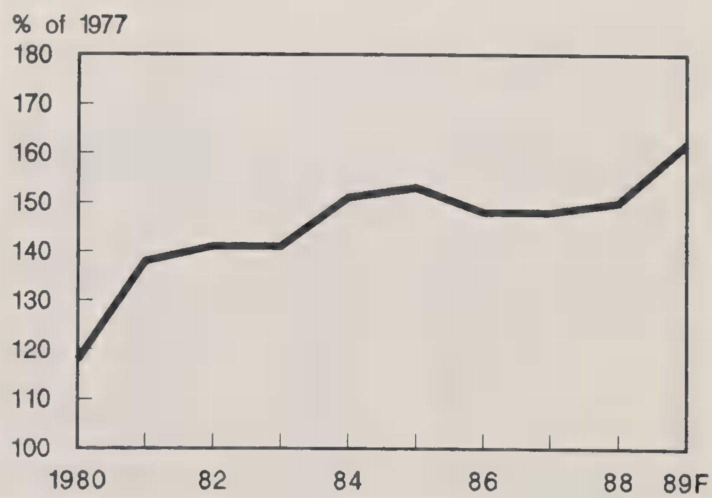
A decline in U.S. soybean seed supplies would likely affect exports to Italy, Mexico, Canada, Turkey, and Japan—the major U.S. soybean seed buyers. Soybean seed exports have already dropped more than 50 percent during the first 9 months of 1988 (table 33). In Canada and Mexico, the 1988 drought discouraged soybean planting, which in turn reduced seed demand. Exports to Italy are apparently down due to decreased planted acreage in 1988 and EC phytosanitary restrictions.

Forage seed supplies in 1989 are expected to be adequate, because the Pacific Northwest grass-growing region, which produces a large part of U.S. forage seed, did not suffer in the 1988 drought. One measure of the supply of grass seed for 1989 is the number of grass seed acres certified in 1988. Due to greater domestic and foreign demand, North American certified grass seed acreage rose in 1988 (table 34). Increases ranged from 6 percent for orchardgrass to 72 percent for all wheatgrass. Although certified grass seed is not required for CRP plantings, Federal and State conservation agencies recommend using certified seed when available.

Prices

Higher demand and lower supply will probably increase USDA's prices paid index by 10 to 15 percent in 1989. Prices of field seeds, particularly corn and soybeans, are expected to jump significantly in spring 1989 due to drought-reduced seed supply, expensive off-season seed corn

Seed Price Index



1989 forecast.

production, and greater projected planted acreage. Several seed corn firms have announced average increases of 10-15 percent in the spring price. Soybean, wheat, oat, and barley seed prices tend to follow commercial crop prices, which have climbed substantially since the beginning of 1988. Cotton prices, however, have fallen over the last year.

If yields on the greater certified grass seed acreage are normal, grass seed supplies should rise. However, if CRP and foreign demand for grass seed continue or grow stronger, upward pressure will be placed on prices in 1989. Between 1985 and 1988, grass seed prices for timothy and annual ryegrass increased 124 and 28 percent, respectively.

Seeding Rate and Seed Cost Per Acre

The combination of seeding rate and seed price determine seed cost per acre. Costs vary substantially by State and by crop. Locations where crops are mostly irrigated, as in California, or grown where rainfall is normally abundant, as in the eastern Corn Belt, support heavier seeding rates and consequently higher seed costs per acre.

Corn

The average seeding rate for the 10 leading corn-producing States in 1988 was 24,100 kernels per acre, slightly higher than 1987; this led to an increased average cost of $18.64 per acre (table 35). In 1987, the average cost per acre was $18.30.

The plant population per acre for the 10 States fell 6 percent in 1988, largely because of extremely dry conditions. The field emergence rate dropped to 85 percent in 1988, compared to 91 percent in 1987.

The seeding rate (and therefore seed cost per acre) varied considerably across the Corn Belt, primarily because of soil productivity and moisture availability. For example, Minnesota had the highest seeding rate and cost per acre; South Dakota, on the other hand, typically has lower and more variable precipitation than other corn-growing States, which encourages low seeding rates.

Table 35.--Corn for grain seeding rates, plant population, and seed cost per acre, 1988 1/

States	Acres planted	Rate per acre	Plant population per acre	Cost per acre
	1,000	Kernels	Number	Dollars
IL	9,900	25000	21900	18.63
IN	5,200	24000	20700	18.32
IA	11,300	24700	22100	19.16
MI	2,100	23700	20500	19.43
MN	5,700	25800	23600	21.44
MO	2,200	20800	17800	16.48
NE	6,900	24100	21900	18.21
OH	3,300	25500	21000	19.95
SD	3,150	18000	16200	14.35
WI	3,450	24400	20400	17.18
Area	53,200	24100	20610	18.64

1/ States planted 79 percent of U.S. corn acres in 1988.

Table 36.--Soybeans seeding rates, seed cost per acre, and percent seed purchased, 1988 1/

States	Acres planted	Rate per acre	Cost per acre	Acres with purchased seed
	1,000	Pounds	Dollars	Percent
AR	3,250	52	9.23	55
GA	900	51	10.86	63
IL	8,800	61	13.21	74
IN	4,300	59	11.73	77
IA	7,950	60	13.70	77
KY	980	60	10.96	78
LA	1,800	57	12.58	97
MN	4,900	68	12.20	71
MS	2,400	52	9.44	76
MO	4,300	59	11.61	64
NE	2,400	58	13.06	80
NC	1,470	59	12.36	78
OH	3,900	75	14.70	71
TN	1,400	51	10.05	66
Area	48,750	62	12.86	73

1/ States planted 83 percent of U.S. soybean acres in 1988.

Soybeans

The average seeding rate for soybeans was 62 pounds per acre in 1988, whereas the average seed cost per acre was $12.86 (table 36). Seeding rates tend to be lower in the southern States (Arkansas, Georgia, Mississippi, Tennessee, and Louisiana). Northern States, which have higher seeding rates and yields, exhibit higher seed cost per acre.

For the States surveyed in 1988, farmers used purchased soybean seed rather than homegrown seed on 73 percent of soybean acres as in 1987. The share of acres sown with purchased seed varied widely, ranging from a low of 55 percent in Arkansas to a high of 97 percent in Louisiana. Among surveyed States, Louisiana has had the highest share of acres sown with purchased seed for the last 3 years.

The choice of purchased versus homegrown seed is affected by many factors, such as difference in cost and yields. For example, USDA's price estimate of purchased soybean seed, as of April 1988, was $11.90 per bushel. The Chicago wholesale price for No. 1 yellow soybeans for the same month was $6.64 per bushel, a measure of the cost the farmer bears when using homegrown seed. Although the cost difference of $5.26 per bushel appears to be a substantial savings, other considerations enter into the equation. Homegrown seed must be cleaned and inoculated before planting, germination tests should be performed, and, in some instances, the seeding rate may have to be increased. Furthermore, the yield potential of a new variety may exceed that of the older variety.

Winter wheat

The average seeding rate per acre for winter wheat was 75 pounds in 1988, an increase of 4 percent from 1987. But the average cost was $7.67 per acre, up 27 percent from 1987,

Table 37.--Wheat seeding rates, seed cost per acre, and percent seed purchased, 1988 1/

States	Acres harvested	Rate per acre	Cost per acre	Acre with purchased seed
	1,000	Pounds	Dollars	Percent
		Winter		
AR	1,050	130	11.05	75
CA	440	128	13.02	75
CO	2,350	43	3.17	36
ID	790	89	9.38	66
IL	1,220	110	12.42	69
IN	700	119	14.60	64
KS	9,400	60	5.64	29
MO	1,550	116	10.88	64
MT	2,100	60	5.22	18
NE	2,000	66	4.01	33
OH	920	134	14.63	64
OK	4,800	72	5.08	36
OR	660	88	8.55	64
TX	3,100	70	6.80	47
WA	1,750	66	6.59	60
Area	27,390	75	7.67	53
		Spring		
ID	380	109	13.04	74
MN	2,000	112	10.79	57
MT	1,500	62	4.79	22
ND	4,600	90	7.53	48
SD	1,300	85	8.07	30
Area	9,780	90	8.58	46
		Durum		
ND	2,500	99	8.05	47

1/ States harvested 69 percent of U.S. winter wheat acres, 95 percent of U.S. spring wheat, acres, and 85 percent of U.S. durum wheat in 1988.

reflecting higher prices and seeding rates per acre in 1988 (table 37). Ohio, Indiana, California, Illinois, Arkansas, and Missouri had consistently high seeding rates. Colorado had the lowest seeding rate and cost per acre. More than 50 percent of the wheat acreage was sown with purchased seed in 1988, compared to 40 percent of the acreage in 1987 and 1986. This increase may reflect the farmer's improved financial condition over the last 3 years.

Spring and durum wheat

The average spring wheat seeding rate in 1988 was 90 pounds, and seed cost was $8.58 per acre (table 37), up from $6.97 per acre in 1987. Less than 50 percent of the spring wheat acreage was planted with purchased seed, as farmers attempted to hold down production costs. In April 1988, the price of purchased spring wheat seed was $5.89 per bushel, whereas farmers received $2.79 per bushel. However, considerable variations occur among States.

The seeding rate for durum wheat in 1988 was 99 pounds, and the cost was $8.05 per acre (table 37). The acreage sown with purchased seed increased from 44 percent in 1987 to 47 percent in 1988.

Table 38.--Rice seeding rates, seed cost per acre, and percent seed purchased, 1988 1/

States	Acres planted	Rate per acre	Cost per acre	Acres with purchased seed
	1,000	Pounds	Dollars	Percent
AR	1,180	124	21.79	74
CA	425	158	26.65	94
LA	525	125	33.64	94
Area	2,130	131	26.22	87

1/ States planted 74 percent of U.S. rice acres in 1988.

Rice

In 1988, the average seeding rate for rice was 131 pounds per acre, and the average seed cost was $26.22 (table 38). California had the highest seeding rate, while Louisiana had the highest costs per acre, demonstrating that Louisiana had higher seed prices than California. In both States, 94 percent of the acreage was planted with purchased seed; in Arkansas, on the other hand, less than 75 percent of the acreage was planted with purchased seed.

Cotton

In 1988, the average seeding rate for cotton was 18 pounds, and seed cost was $8.38 per acre (table 39), a slight decrease

Table 39.--Cotton seeding rates, seed cost per acre, and percent seed purchased, 1988 1/

States	Acres planted	Rate per acre	Cost per acre	Acres with purchased seed
	1,000	Pounds	Dollars	Percent
AZ	340	15	9.52	84
AR	680	13	6.27	92
CA	1,350	18	12.10	90
LA	700	13	6.60	99
MS	1,230	13	7.15	97
TX	5,400	20	8.13	51
Area	9,700	18	8.38	86

1/ States planted 81 percent of U.S. cotton acres in 1988.

Table 40.--U.S. seeds for planting export and imports 1/

Item	1983	1984	1985	1986	1987	Change 86-87
	Million dollars					Percent
Exports:						
Forage	65	70	59	74	75	1
Vegetables	114	119	120	128	140	9
Flower	6	9	8	9	8	-11
Corn 2/	73	46	89	77	63	-18
Grain sorghum	32	33	33	29	16	-44
Soybeans	12	19	17	19	36	89
Trees/shrubs	2	2	2	2	2	0
Sugarbeet	4	3	2	2	1	-50
Others	22	21	28	31	33	6
Total	330	322	358	371	374	1
Imports:						
Forage	34	17	18	39	65	66
Vegetables	31	32	34	42	49	18
Flower	10	18	18	18	21	17
Corn 3/	6	22	14	9	5	-44
Trees/shrubs	1	1	1	1	1	0
Others	2	1	2	3	4	33
Total	84	91	87	112	145	25
Trade balance	246	232	271	258	229	-11

1/ Totals may not add due to rounding. 2/ Not sweet, not food aid. 3/ Certified.

Source: U.S. Department of Commerce, Bureau of Census, Foreign Trade Division.

over 1987. Texas had the highest seeding rate per acre in 1988 and 1987. California had lower seeding rates than Texas, but its seed cost per acre was higher, reflecting its higher seed price. The acres planted with purchased seed increased from 81 percent in 1987 to 86 percent in 1988.

Exports

U.S. planting seed exports during calendar year 1987 set a new record of $374 million, about 1 percent above 1986 (table 40). The 1987 increase was primarily due to soybean and vegetable seeds, which were up 89 percent and 9 percent, respectively, over the previous year. These gains were partly offset by declines in sugar beet, grain sorghum, corn, and flower seeds. These decreases ranged from 11 percent for flower seeds to 50 percent for sugar beet seeds.

Italy, Mexico, Japan, Canada, the Netherlands, and France continued to be the top markets for U.S. planting seeds, accounting for 64 percent of total export value in 1987 (table 41). Italy (with 19 percent of the total) held first place for the second consecutive year, followed by Mexico (13 percent), Japan (12 percent), Canada (9 percent), the Netherlands (5 percent), and France (4 percent). In 1985 and earlier years, Mexico was the leading export market, and Japan was in second place, followed by Italy or Canada. Saudi Arabia has intermittently been a major seed customer; the inconsistency in its purchases is due to its effort to produce rather than import agricultural commodities. On a regional basis, Western Europe, North and Central America, and Asia typically account for over 80 percent of the total export value.

U.S. forage and turf seed exports reached $75 million, a 1-percent increase over 1986. The major markets for these exports were Canada ($16 million), Japan ($15 million), Mexico ($8 million), Italy ($5 million), and Argentina ($4 million). These countries accounted for 64 percent of total forage and turf seed exports.

Table 41.--Export values for U.S. seeds for planting, region and country shares

Region, country	1983	1984	1985	1986	1987
			Percent		
North and Central America:					
Canada	8.8	8.9	7.4	6.3	9.4
Mexico	21.9	19.6	15.1	12.4	13.0
Others	2.1	2.7	2.5	2.0	2.3
Total	32.7	31.3	25.0	20.7	24.7
South America:					
Brazil	2.0	1.0	1.1	1.1	1.2
Argentina	1.0	2.0	1.1	2.5	2.5
Columbia	1.2	1.4	0.8	1.0	0.9
Venezuela	1.9	2.2	2.9	3.0	1.4
Others	1.9	2.1	1.1	1.3	1.5
Total	8.0	8.7	7.0	9.0	7.6
Western Europe:					
United Kingdom	2.6	2.2	2.7	2.8	2.6
Netherlands	4.8	3.5	4.6	5.8	5.4
France	4.9	4.1	9.6	6.2	4.5
West Germany	2.0	1.7	1.8	1.7	1.6
Spain	1.0	1.3	1.4	1.6	2.1
Italy	8.5	8.3	12.5	12.7	19.3
Greece	1.7	1.4	1.9	2.3	1.3
Others	4.2	3.9	3.1	3.4	2.8
Total	29.8	26.4	37.5	36.5	39.7
Eastern Europe:					
Hungary	0.1	0.1	2.9	0.6	0.1
Bulgaria	0.1	0.0	0.0	3.0	0.0
Others	0.9	0.4	0.4	1.2	0.1
Total	1.1	0.5	3.3	4.8	0.2
Asia:					
Turkey	0.5	0.7	1.3	3.0	2.0
Iraq	2.1	3.3	2.5	2.2	1.8
Saudi Arabia	3.1	4.5	2.8	3.6	2.0
Japan	11.2	11.4	10.7	9.6	12.3
South Korea	0.7	1.5	0.8	0.9	1.0
Others	3.7	5.0	3.8	4.6	3.6
Total	21.3	26.4	21.9	23.9	22.6
Africa:					
South Africa	2.3	1.3	0.8	1.2	1.5
Egypt	1.0	1.2	1.0	0.6	0.8
Others	1.2	2.1	1.1	1.4	0.7
Total	4.4	4.7	2.9	3.2	3.0
Oceania:					
Australia	2.2	1.5	2.0	1.6	1.8
New Zealand	0.4	0.4	0.4	0.3	0.3
Others	0.0	0.0	0.0	0.0	0.1
Total	2.6	2.0	2.4	1.9	2.2
Total 1/	100.0	100.0	100.0	100.0	100.0

1/ Total may not add due to rounding.

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

Top markets for U.S. vegetable seeds were Japan ($21.6 million), Mexico ($21.5 million), Italy ($15.4 million), the Netherlands ($9.6 million), and Canada ($8 million), accounting for 55 percent of the total value of the export market.

U.S. corn seed exports in 1987 declined to $63 million, 11 percent lower than in 1986. Four of the top six markets were members of the EC: Italy ($27.4 million), France ($6.3 million), Spain ($3.9 million), and Greece ($3.8 million). Mexico and Japan accounted for $6.2 million and $4.8 million, respectively. These countries together accounted for 83 percent of the total value of the corn seed export market.

U.S. soybean seed export value was $36 million, an 89-percent increase over 1986. Italy continued to provide the largest market for soybean seed exports, accounting for 59 percent of the total. Other important markets were Mexico, Turkey, Japan, and Canada. These five countries accounted for 96 percent of the total export value.

U.S. grain sorghum seed exports declined 44 percent in 1987, following a 14-percent decrease in 1986. Mexico, with 38 percent of total exports, provided the largest market. Other important markets were Venezuela, Columbia, and Saudi Arabia. These four countries accounted for 69 percent share of the total exports.

Imports

U.S. imports of planting seeds for calendar year 1987 totaled $145 million, a 25 percent jump from the previous year (table 40). In 1986, import value rose 29 percent. Most of the increase in import value for both years was due to forage

Table 42.--Import values for U.S. seeds for planting, region and country shares

Region, country	1983	1984	1985	1986	1987
			Percent		
North and Central America:					
Canada	44.1	26.1	26.7	35.1	37.7
Mexico	3.6	2.8	4.0	2.9	2.0
Guatemala	1.6	2.9	2.3	2.7	2.5
Costa Rico	2.7	4.6	4.8	2.6	2.1
Others	0.1	0.3	0.6	0.1	0.1
Total	52.1	36.7	38.5	43.4	44.4
South America:					
Chile	3.3	10.0	8.2	6.2	4.0
Others	0.2	0.3	1.0	0.8	2.0
Total	3.6	10.3	9.2	7.0	6.0
Western Europe:					
Denmark	0.6	0.8	1.6	1.2	2.1
United Kingdom	2.0	0.7	0.8	0.6	0.8
Netherlands	6.5	10.7	11.7	10.5	10.2
France	1.4	1.3	1.4	1.1	1.7
West Germany	0.7	1.3	1.4	2.2	2.5
Italy	1.2	1.1	1.7	1.1	1.2
Others	1.3	0.9	2.4	1.9	0.7
Total	13.8	16.8	21.0	18.7	19.2
Eastern Europe:					
Yugoslavia	0.2	0.8	1.4	0.0	0.0
Rumania	0.0	5.3	0.2	0.1	0.0
Others	0.1	1.1	0.2	0.4	0.5
Total	0.4	7.2	1.8	0.4	0.5
Asia:					
India	4.6	1.7	3.3	6.5	2.9
Taiwan	7.6	10.1	7.6	6.0	6.7
Japan	5.1	5.9	6.1	6.1	6.0
Others	3.8	3.7	3.0	3.6	3.8
Total	21.2	21.3	20.1	22.2	19.4
Africa:					
Ethiopia	3.9	3.3	4.4	2.8	3.0
South Africa	1.4	1.8	0.9	0.5	0.1
Others	1.0	0.6	1.0	0.6	0.8
Total	6.3	5.7	6.4	4.0	3.9
Oceania:					
Australia	1.3	1.3	2.2	1.8	2.1
New Zealand	1.4	0.7	0.8	2.6	4.5
Others	0.0	0.0	0.0	0.0	0.0
Total	2.7	2.0	3.0	4.3	6.5
Total 1/	100.0	100.0	100.0	100.0	100.0

1/ Total may not add due to rounding.

Source: U.S. Department of Commerce, Bureau of the Census, Foreign Trade Division.

seeds used to satisfy the CRP requirements. Flower and vegetable seed imports rose 17 percent and 5 percent, respectively, in 1987. Conversely, imports of certified corn seed fell 44 percent.

Canada continued to be the leading supplier of planting seeds, with about 38 percent of total seed imports (table 42). The Netherlands, with 10 percent, remained the second largest source, followed by Taiwan (7 percent) and Japan (6 percent).

Among regions, the largest share of seed imports came from North and Central America, accounting for 44 percent ($65 million) of the total. Although imports from Asia dipped slightly in 1987 to 19 percent ($28.2), it remained the second leading source of imports. Asia was followed by Western European imports, valued at $28 million.

In 1987, the U.S. trade surplus in planting seeds dropped to $229 million, showing a decline for the second consecutive year (table 40). This reduction can be attributed primarily to a 66-percent increase in forage seed imports and decreases in corn and grain sorghum exports. For the first 9 months of 1988, U.S. seed exports totaled $274 million, 13 percent greater than the same period in 1987. Imports from January-September 1988 were $111 million, slightly below the 1987 level.

FARM MACHINERY

Demand

Farm machinery expenditures in 1988 are expected to have continued the upswing that began in 1987. Although the drought of 1988 adversely affected sales, total expenditures for farm machinery last year likely exceeded 1987 levels by 5 to 10 percent. Machinery expenditures are expected to rise another 6 to 12 percent in 1989, reaching $6.4 to $7.1 billion (table 43).

The drought, improved farm equity, and the increasing age of the farm machinery stock will likely have a significant in-

fluence on 1989 farm machinery sales prospects. A continuing rise in land prices not only improves farm equity, but indicates optimism on the future profitability of agriculture.

Sales of new farm machinery units increased for most machine categories in 1988 (table 44). The drought probably caused the 16-percent fall in sales of self-propelled combine units. An increase in commodity prices and planted acreage are expected to strengthen sales of new tractors and combines in 1989.

Other factors also influence farm machinery sales. Prices of used farm machinery appeared to increase significantly in 1987, when demand for this equipment showed improvement for the first time this decade. The portion of farmers reporting leasing or custom hiring activities and the related

Table 43.--Trends in U.S. farm investment expenditures and factors affecting farm investment demand

Item	1984	1985	1986	1987	Preliminary 1988	Forecast 1989
			Billion dollars			
Capital expenditures:						
Tractors	2.54	1.94	1.51	1.85	1.9-2.3	2.1-2.5
Other farm machinery	4.68	3.65	3.09	3.92	4.0-4.4	4.2-4.6
Total	7.22	5.59	4.61	5.77	5.9-6.5	6.4-7.1
Tractor and machinery repairs	3.8	3.7	3.7	3.9	4.0	4.0-4.5
Trucks and autos	2.0	1.8	1.7	1.9	1.7	2.0-2.6
Farm buildings 1/	3.3	2.3	2.1	2.2	2.4	2.4-2.6
Factors affecting demand:						
Interest expenses	21.1	18.7	16.9	15.5	16	15-17
Total production expenses	143	134	122	124	132	136-140
Outstanding farm debt 2/ 3/	204	188	167	153	150	149-157
Farm real estate assets 2/	694	606	554	567	599	610-620
Farm nonreal estate assets 2/ 3/	256	240	235	247	251	253-263
Agricultural exports 4/	38.0	31.2	26.3	27.9	35.3	36.5
Net farm income	32.0	32.3	37.5	46	39	44-48
Net cash income	38.7	46.6	51.4	57.1	57	48-52
Direct government payments	8.4	7.7	11.8	16.7	14	10-12
			Million acres			
Diverted acres 5/	27	31	48.1	75.5	78.3	na
			Percent			
Real prime rate 6/ 7/	8.3	6.9	5.8	4.9	6.1	7.0
Nominal farm machinery and equipment loan rate 8/	14.6	13.7	12.2	11.5	11.7	na
Real farm machinery and equipment loan rate 7/	10.8	10.7	9.5	8.2	8.5	na
Debt-asset ratio 9/	21.5	22.2	21.4	18.8	17.6	17-18

na = Not available.

1/ Includes service buildings and structures and land improvements. 2/ Calculated using nominal dollar balance sheet data, including farm households for December 31 of each year. 3/ Excludes CCC loans. 4/ Fiscal year. 5/ Includes acres idled through commodity programs and acres enrolled in the Conservation Reserve. 6/ Monthly average. 7/ Deflated by the GNP Deflator. 8/ Average annual interest rate. From the quarterly sample survey of commercial banks: Agricultural Financial Databook, Board of Governors of the Federal Reserve System. 9/ Outstanding farm debt (including households) divided by the sum of farm (including households) real and nonreal estate asset values.

Table 44.--Domestic farm machinery unit sales

Machinery category	Annual average 1978-80	Annual average 1981-84	1985	1986	1987	Preliminary 1988	Forecast 1989	Change 87-88	Change 88-89
				Units					Percent
Tractors:									
Two-wheel drive									
40-99 hp	62,818	42,131	37,847	30,848	30,718	33,083	34,000	8	3
Over-99 hp	59,543	31,272	17,700	14,262	15,911	16,127	17,500	1	9
Four-wheel drive	10,276	6,385	2,912	2,037	1,653	2,729	3,100	65	14
Grain and forage harvesting equipment:									
Self-propelled combines	29,834	16,805	8,411	7,660	7,172	5,995	7,300	-16	22
Forage harvesters 1/	11,145	5,093	2,460	2,164	2,280	2,406	2,550	6	6
Haying equipment:									
Balers 2/	17,501	9,975	7,038	5,734	5,352	5,732	6,100	7	6
Mower conditioners	23,392	14,954	11,243	10,898	11,239	11,041	11,500	0	4

1/ Shear bar type. 2/ Producing bales up to 200 pounds.

Source: Historical data are from the Farm and Industrial Equipment Institute (FIEI). All 1989 values are ERS forecasts.

expenditures have apparently remained stable since 1984. Farm machinery exports and imports in the first three-quarters of 1988 increased for the second year in a row, with 24 and 31 percent gains, respectively.

Effects of the 1988 Drought

The 1988 drought hurt farm machinery sales in 1988, but will likely lead to higher sales in 1989. Farm machinery sales in the latter half of 1988 slipped as the extent of the drought became apparent. Farmers who saw yields declining delayed purchases of tractors, combines, and other equipment. However, farmers who did raise crops saw higher commodity prices and thus, in some cases, found it advantageous to replace or upgrade their equipment.

Farm net cash income in 1988 probably equalled 1987's record $57 billion, partly because of Federal drought relief and higher prices received by those who did raise crops. However, the level of net cash income in 1988 did not support farm machinery demand as it has in the past because the distributional effects of the drought resulted in greater-than-normal income variations.

Because the drought lowered program commodity stocks, there is more optimism about future crop prices, and planted acreage is therefore expected to rise. In addition, farm program acreage reduction requirements have been reduced for wheat and feed grains. More acres in production and greater optimism about crop prices will raise farm machinery demand.

Aging Stock of Farm Machinery

An important factor influencing farm machinery purchases is the added productivity that a new machine may offer. Productivity gains depend on the repair and maintenance costs of the current unit, as well as on technological improvements of the newer unit. Because farmers still face historically high real interest rates, the improved efficiency of new machinery must be high enough to make the investment cost effective.

Some strength in the 1988 and 1989 farm machinery demand can be attributed to the aging of the machinery stock. Depressed conditions in the farm sector from 1980 to 1987 led many farmers to delay capital purchases. Industry sources indicate that manufacturers, although hurt by the reduced sales, have continued their research and development programs.

Improved Farm Equity

Farm equity improvements also strengthen farm machinery demand, since an improved equity position reduces foreclosure risks.

Farm equity in 1988 likely improved, as farm debt approached its lowest level since 1980 and farm asset values continued to rise. Rising asset values in 1989 could lower the farm debt-asset ratio to near its 1980 level (17 percent).

Movements in farm asset values not only improve farm equity, but indicate expectations of future farm profitability. Although increased optimism in agriculture has led to rising land values—a major component of total farm assets—the rate of increase is less than the rate of inflation.

Government Programs

The Government continues to play a key role in agriculture through acreage reduction requirements for program participants, direct Government payments, commodity price guarantees, crop insurance, and the Export Enhancement Program. The lowering of the acreage reduction requirement, together with the subsequent increase in planted acreage, increases the level of machinery use and, therefore, boosts farm machinery demand. Direct Government payments to agriculture peaked in 1987 at $16.7 billion. Payments are expected to have been lower in 1988, but should still exceed the 1986 level of $11.8 billion; 1989 payments are expected to fall to 1986 levels or below. Although decreasing, these income transfers are still high by historical standards and will continue to support farm machinery sales.

However, the 1985 Food Security Act is attempting to decrease the Government's role in agriculture by gradually reducing target prices, freezing program yields, and lowering loan rates. The Act will have two offsetting effects on farm machinery sales, at least through 1990. Fixing program yields, lowering loan rates, and lowering target prices will reduce the expected return to, and investment in, farm machinery. But decreasing program participation will increase acres planted and farm machinery use. Because these changes are gradual, the net effect on farm machinery sales will likely be insignificant.

Unit Sales

Sales of new farm machinery in 1988 indicate an overall improvement in demand. However, the dampening effect of the drought is evidenced by a 16-percent fall in combine sales. Despite the drought, sales of tractors improved over a year earlier.

The 65-percent growth in sales of four-wheel drive tractors reflects, in part, their extremely depressed levels since 1979. The nearly stable sales of the over-99 horsepower (hp) tractors in 1988 belie the strength of the demand for these units, since sales in 1987 were boosted by price reductions as high as 60 percent.

Sales of all categories of new units in 1989 may return to their 1985 levels. Although the growth in sales continues to be good news for farm machinery manufacturers, there is still significant room for improvement. Within most machine categories, 1989 sales will likely approach only one-third of their 1978-80 annual average. Combines are expected to show the largest growth next year. Combine sales are forecast to increase 22 percent over their drought-reduced 1988 level.

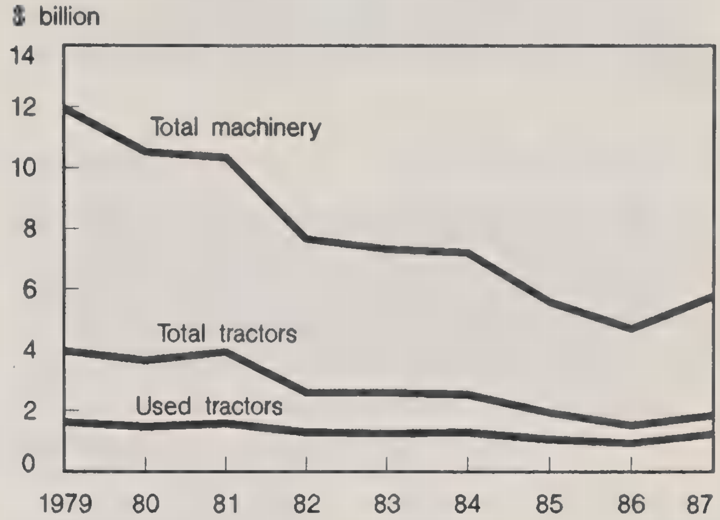
Farm Machinery Supply

Excess inventories of farm machinery have been a problem for manufacturers and dealers since the 1980 downturn in demand. These inventories created a buyers' market for farm machinery until 1987. Manufacturers' cuts in production rates, sales incentives, the continued wear on machines in use, and improved demand eliminated the excess supply.

As demand for farm machinery began to rise in 1987, so did prices of used farm machinery. Although sticker prices on new units do not react as abruptly as prices on used units, the loss of sales incentives represents an increase in the cost of new machinery.

Evidence of increases in tractor prices is obtained by comparing levels of farm machinery expenditures with the number of units sold. Although farm machinery expenditures rose 25 percent during 1987, sales of new over-99 hp tractors showed mild gains, while sales of other tractors and combines declined. Expenditures on new tractors in 1987 were up 6 percent from $571 million in 1986, and expenditures on used tractors were up 32 percent from $1.2 billion. However, the portion of farmers reporting tractor purchases was down slightly in 1987. Thus, the rise in tractor expenditures in 1987 likely reflects price increases more than an increase in the number of units sold. The same price reaction may have occurred in the markets for other farm machinery.

U.S. Farm Machinery Expenditures



Leasing, Renting, and Custom Hire

Farmers can decrease their investment in farm machinery by relying more on leasing (renting) or custom hiring. The most common of these practices is custom combining. Because a combine requires a significant investment and harvesting must be done within a short time (especially for small grains), the farmer who owns a combine may use the machine for a relatively brief period each year. Custom combining operators take advantage of different harvesting seasons across the country and consequently use the machine much more intensely.

Expenditures for custom hiring and leasing totaled $1.9 billion dollars in 1987, up slightly from 1986 but still below

Table 45.--Leasing and custom hire expenditures for tillage and harvesting

Item	1984	1985	1986	1987
	Million dollars			
Crop custom hire:	na	1,736	1,372	1,511
Tillage and cultivation	102	63	84	114
Planting and seeding	59	54	71	86
Harvesting	1,092	1,387	1,011	1,146
Other	na	232	206	165
Leasing: 1/	487 2/	427	419	429
Tractors	142	161	142	153
Other machinery	345 2/	266	277	276
Irrigation equipment	na	47	39	51
	Percent			
Percent of farms reporting:				
Crop custom hire services	na	40	40	38
Machinery leasing services	na	8.0	7.6	6.3
Tractor leasing services	2.3	3.0	2.9	2.8

na = Not available.

1/ Includes tractors, other farm machinery, self-propelled machinery, fertilizer and irrigation equipment, trucks, autos, farm service and storage structures, and other motor vehicles (leased or rented).
2/ Excludes farm service and storage structures.

1985 (table 45). Custom hiring expenditures include compensation for the machine and the operator. Total farm machinery expenditures in 1987 were $5.8 billion, while custom hiring plus leasing expenditures were about one-third that amount.

Farm Machinery Trade

The value of farm machinery imports and exports during the first three-quarters of 1988 exceeded year-earlier levels for the second consecutive year (table 46). Exports increased 24 percent, and imports increased 31 percent, for a $62-billion decrease in the farm machinery trade balance for the first 9 months of 1988 compared with 1987. The value of tractor exports and imports grew 33 and 35 percent, respectively, driving much of the change in farm machinery trade.

Canada remains the largest farm machinery trading partner of the United States. Approximately one-third of U.S. total exports and one-fourth of its total imports of agricultural machinery are with Canada. However, Canada was the only large U.S. trading partner to buy less total farm machinery during the first 9 months of 1988.

Tractors remain the most significant component of U.S. farm machinery trade, representing almost two-thirds of both im-

Table 46.--Farm machinery trade situation

Country, area 1/	January - September 1987	1988	Change 87-88
	Million dollars		Percent
Tractors 2/			
Exports to:			
Canada	293.3	337.4	15
France	46.5	76.2	63
Australia	35.2	73.1	108
United Kingdom	40.8	68.9	69
Mexico	48.1	57.6	20
Japan	34.8	37.3	7
West Germany	34.2	36.9	8
South Africa	12.9	22.2	73
All others	306.7	424.2	38
Total	852.5	1133.9	33
Imports from:			
Japan	268.2	301.2	12
United Kingdom	149.4	242.2	62
West Germany	136.1	171.4	26
Canada	85.9	103.2	20
Italy	75.5	95.3	26
France	16.0	51.6	223
Brazil	6.5	12.9	97
South Korea	4.4	9.6	119
All others	69.2	109.9	59
Total	811.3	1097.3	35
Machinery 3/			
Exports to:			
Canada	298.6	228.8	-23
Australia	10.0	36.5	265
France	34.4	34.6	1
Mexico	16.9	34.2	103
Venezuela	18.4	27.0	47
United Kingdom	14.9	20.7	39
Belgium	10.0	15.9	60
Japan	7.7	14.2	85
West Germany	10.1	14.2	41
All others	113.1	152.8	35
Total	534.1	578.9	8
Imports from:			
Canada	234.0	265.7	14
West Germany	47.7	55.6	17
France	25.4	43.6	71
Italy	35.6	42.4	19
United Kingdom	16.5	30.9	88
Netherlands	18.7	21.3	14
New Zealand	7.2	10.1	41
All others	72.5	90.1	24
Total	457.6	559.8	22
Tractor and machinery			
Exports, total	1386.6	1712.8	24
Imports, total	1268.9	1657.1	31
Trade surplus	117.7	55.7	-53

1/ Countries are listed in order of significance in 1988.
2/ Includes tractor parts and excludes new non-agricultural tractors. 3/ Includes agricultural and horticultural machinery and parts. This category does not include lawn and garden machinery.

Source: United States International Trade Commission.

ports and exports. Machinery exports are distributed over a significantly larger number of countries than are imports. The industrialized countries, where most of the agriculture is mechanized, tend to be more significant importers and exporters of farm machinery.

The fall in the dollar's value relative to currencies of importing countries is likely the major factor driving farm machinery exports. In those countries, U.S. exports will cost less in terms of the local currency. Therefore, U.S. exports to those countries rise as importers take advantage of the lower cost.

Growth in domestic farm machinery demand will likely increase machinery imports. The movement of nearly all midsized two-wheel drive production to Europe during the 1970's requires that these tractors be imported. Farm machinery manufacturers moved tractor production abroad because of the high value of the dollar during the early 1980's; Europe represented a significant market for midsized tractors; and European trade barriers and taxes on farm machinery imports could be circumvented. Sources within the industry indicate that a decline in the dollar's value may have begun to reverse this trend.

Exports will likely continue grow to through 1989 as the dollar's value maintains the competitiveness of U.S. farm machinery production. Imports will also likely keep on growing through 1989 as the improved farm economy continues to boost demand. If the dollar maintains its present exchange value, imports in the early 1990's may slip as manufacturers reverse the movement of production abroad.

ENERGY

U.S. farmers can expect energy prices to edge up in 1989 due to higher crude oil prices. Farm fuel prices rose slightly in 1988. As a result of higher crude oil prices in the last quarter of 1988 (due to OPEC's agreement to restrain production), average petroleum product prices paid by farmers should rise throughout 1989. Higher energy prices and expansions in planted acreage will increase farmers' energy expenditures in the coming year.

Oil Consumption and Production

OPEC's November 1988 agreement called for a price target of $18 per barrel and a reduction of its output from the current 17-year high of 22.5 million barrels per day to 18.5 million per day for the first 6 months of 1989. The agreement brings Iraq back into the cartel fold with a quota equivalent to that of Iran. Total world consumption of petroleum for 1988 increased 2.7 percent to 50.1 million barrels per day, the highest level since 1979. World inventories at the end of 1988 were slightly lower than a year earlier.

Table 47.--U.S. petroleum consumption-supply balance

Item	1986	1987	1988	Forecast 1989
	Million barrels per day			
Consumption:				
Motor gasoline	7.03	7.21	7.34	7.44
Distillate fuel	2.91	2.98	3.09	3.19
Residual fuel	1.42	1.26	1.25	1.20
Other petroleum 1/	4.92	5.22	5.33	5.38
Total	16.28	16.67	17.01	17.21
Supply:				
Production 2/	10.96	10.68	10.55	10.36
Net imports (excludes SPR)	5.38	5.84	6.23	6.79
Net stock withdrawals	-0.21	0.05	0.23	0.05
Total	16.28	16.67	17.01	17.21
	Percent			
Net imports as a share of total supply	33	35	37	39
	Percent change from previous year			
Consumption		2.4	2.0	1.2
Production		-2.6	-1.2	-1.8
Imports		8.6	6.7	9.0

SPR = Strategic Petroleum Reserve, October 1988 projections
1/ Includes crude oil product supplied, natural gas liquid (NGL), other hydrocarbons and alcohol, and jet fuel.
2/ Includes domestic oil production, NGL, and other petroleum products.

Source: U.S. Department of Energy. Energy Information Administration. Short-Term Energy Outlook, DOE/EIA-0202 (88/4Q). October 1988.

Department of Energy (DOE) forecasts indicate that economic growth of about 2.5 percent will offset higher crude oil prices, and U.S. petroleum consumption will therefore inch up about 1 percent in 1989 (table 47). For the first time since 1980, domestic petroleum demand in 1988 averaged over 17 million barrels per day. Refiners paid an average of $14 per barrel in the last half of the year, 25 percent less than 1987 prices. But prices surged near the end of 1988, and West Texas Intermediate reached $18 per barrel in January 1989. Crude oil prices are expected to range from $15 to $20 per barrel in 1989.

Domestic production of crude oil will probabaly slacken again in 1989, down 200,000 barrels per day from 8.2 million barrels per day; production dropped 160,000 barrels per day the previous year. Production fell for the third consecutive year in 1988, and the output of 8.2 million barrels per day was the lowest in 24 years. Expanding demand and decreasing domestic production are expected to boost U.S. net imports in 1989 to 6.8 million barrels per day, or 39 percent of domestic consumption (table 47). This rate may be compared with a record high import of 8.6 million barrels per day in 1977, and a low of 4.3 in 1985.

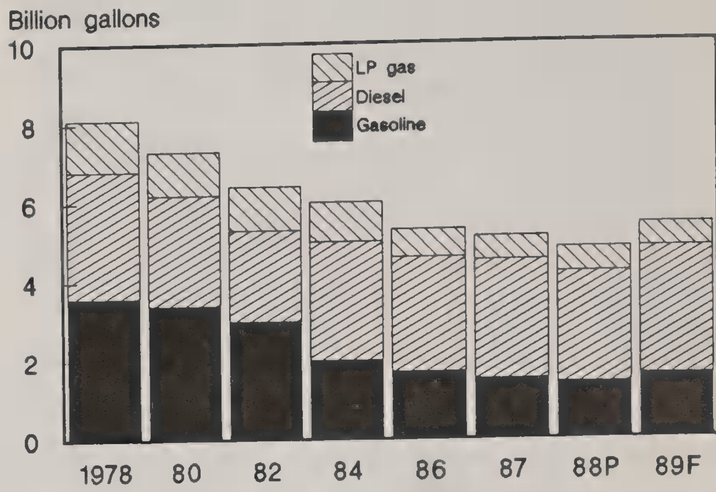
Energy in the Farm Sector

The energy supply and price outlook for U.S. agriculture largely reflects world market conditions, currently characterized by abundant oil supplies priced above 1988 levels. In 1989, farmers can expect plentiful supplies of diesel fuel, gasoline, and LP gas, but at slightly higher prices than last year.

Farm Fuel Use

Combined gasoline and diesel fuel use declined in recent years due to adoption of energy-saving farm production technologies, shifts from gasoline to more efficient diesel-powered units, and generally reduced planted acreage. Although acres planted greatly influences the fluctuations in farm energy use, other factors also have contributed to the decline. Continued replacement of older gasoline machines

Farm Fuel Use



1988 preliminary. 1989 forecast.

with diesel-powered machines, particularly in the production of cotton, rice, and some minor crops, has resulted in greater use of diesel fuel. The 1988 drought contributed to an estimated 5-percent decline in fuel use last year. In many important agricultural regions, the drought's reduction of harvested acres drastically cut harvested yields. In addition, lower grain moisture levels at harvest time decreased energy used for harvesting, drying, and transportation, thereby lessening total fuel use for the year. However, total use of electricity and natural gas increased, partly because the irrigation season started earlier than normal. A return to normal weather and an increase in planted acreage should increase farm fuel use in 1989.

Energy Expenditures Up in 1988

In 1988 farm energy (gasoline, diesel fuel, LP gas, and electricity) expenditures reached an estimated $7.0 billion, up about 3 percent over 1987 (table 48). Declines caused by the drought were offset by higher energy prices and greater reliance on electricity. In 1989, energy expenditures, which comprise about 5.5 percent of total farm production expen-

Table 48.--Farm energy expenditures

	1986	1987	Preliminary 1988	Forecast 1989
	Billion dollars			
Fuels and oil	4.8	4.4	4.0	5.0
Electricity	2.1	2.4	3.0	2.5
Total	6.9	6.8	7.0	7.5
Percent change from preceding year		-1	3	7

Source: U.S. Department of Agriculture. National Agricultural Statistics Service. Farm Production Expenditures, selected issues. Washington, D.C.

ses, are projected to jump 7 percent to $7.5 billion, largely due to an expected 4 to 11 percent increase in planted area of the eight major crops. This will offset long-term reductions in fuel use related to conservation. Higher energy prices will also push up farmers' energy expenditures.

Energy Prices Stable In 1988

In response to moderate movements in world oil prices, farm fuel prices rose only slightly in 1988. Gasoline prices crept up 1 percent, diesel fuel prices rose 3 percent, and LP gas prices held steady. Farmers paid an average of $0.93 per gallon for bulk-delivered gasoline, $0.73 per gallon for diesel fuel, and $0.59 a gallon for LP gas (table 49). In 1989, prices should increase slightly over 1988.

Table 49.--Average U.S. farm fuel prices 1/

Year	Gasoline	Diesel	LP gas
	Dollar per gallon2/		
1979	0.80	0.68	0.44
1980	1.15	0.99	0.62
1981	1.29	1.16	0.70
1982	1.23	1.11	0.71
1983	1.18	1.00	0.77
1984	1.16	1.00	0.76
1985	1.15	0.97	0.73
1986	0.89	0.69	0.67
1987	0.92	0.71	0.59
1988	0.93	0.73	0.59
1989			
January	0.94	0.69	0.57

1/ Derived from surveys of farm supply dealers conducted by the National Agricultural Statistics Service, USDA.
2/ Bulk delivered.

RESIDUE AND TILLAGE SYSTEMS IN 1987 CORN PRODUCTION

by

Len Bull

ABSTRACT: The tillage system used in the production of 1987 corn was determined from a survey of the 10 major corn-producing States. Results indicate that about 81 percent of the 1987 corn was produced with conventional tillage methods (21 percent with a moldboard plow and 60 percent without it). Nearly 14 percent of the corn was produced with mulch tillage, and about 5 percent was produced with no-till methods (1 percent ridge-till and 4 percent no-till). Tillage systems were determined from the estimate of the percentage of soil surface covered by previous crop residue immediately after planting.

KEYWORDS: Tillage systems, conservation tillage, crop residue, residue incorporation.

The use of conservation tillage in crop production can reduce soil loss, lower production costs, and improve water quality. Furthermore, the 1985 Food Security Act requires that an approved conservation plan be implemented for certain highly erodible lands or the farmer will lose the option to participate in most Federal agricultural programs. This conservation compliance provision, in many instances, can be met through changes in tillage practices, rather than construction of permament structures such as terraces or grassed waterways. A clear understanding and definition of tillage systems and their impact is necessary to facilitate the acceptance and implementation of the conservation plans.

This article develops a method for identifying tillage systems based on the amount of crop residue remaining on the field immediately after planting. Tillage operations and the previous crop planted on the field are used to estimate remaining residue. This method allows a standard designation of tillage systems across geographical areas, over time, and across the planting of different crops. It also reduces variance in survey respondents' tillage designations arising from differences in knowledge and interpretation of definitions. This standardization will aid in monitoring the impact of conservation compliance by tracking changes in the adoption of tillage systems.

Most published estimates of the extent of tillage system adoption have been based on surveys asking the farmer for a designation of the tillage system being used or asking Government agencies for estimates of the extent of tillage systems used within a given area (16, 4). These methods rely heavily upon the respondent's knowledge and interpretation of what constitutes a specific tillage system. Consequently, estimates may vary greatly even when the respondent is given specific tillage definitions, especially when residue levels are included in the definitions. Residue levels may not be readily recognizable to farmers or other respondents. Therefore, they may rely mainly on the physical description of tillage operations and not include the residue limitations when designating tillage systems.

Tillage Systems

A commonly accepted definition of tillage systems is used by the Conservation Technology Information Center in its annual survey of conservation tillage practices (4). These definitions have been used in this study and are as follows:

Conservation tillage: Any tillage and planting system that maintains a residue cover of at least 30 percent of the soil surface covered after planting to reduce soil erosion by water; or, where soil erosion by wind is the primary concern, maintains at least 1,000 pounds of flat, small-grain residue equivalent on the surface during the critical erosion period.

Types of conservation tillage:

1. No-till: The soil is left undisturbed before planting. Planting is completed in a narrow seedbed or slot created by a planter or drill. Weeds are controlled primarily with herbicides.

2. Ridge-till: The soil is left undisturbed before planting. Planting is performed on ridges in a seedbed prepared with sweeps, disks, or other row cleaners. Residue is left on the surface between ridges. Weeds are controlled with herbicides and/or cultivation. Ridges are rebuilt during the growing season with cultivation for weed control.

3. Strip-till: The soil is left undisturbed before planting. Tillage in the row may be done with rototillers, in-row

chisels, or row cleaners. Weeds are controlled with herbicides and/or cultivation.

4. Mulch-till: The total surface is disturbed by tillage before planting. Tillage tools such as chisels or field cultivators (disks, sweeps, or blades) are used. Weeds are controlled with herbicides and/or cultivation.

5. Reduced-till: Any other tillage and planting system not covered in definitions 1-4 that meets the 30-percent conservation tillage residue requirement.

Conventional tillage: By default, any system that does not meet the 30-percent conservation tillage residue requirement after planting is designated as conventional tillage.

Methodology

The methodology developed here begins with a percentage estimate of the soil surface covered with residue remaining from the previous crop. That level is then reduced by a specified percentage for each pass of a tillage implement (table 50). The resulting residue level after planting and the use of certain tillage implements determine the tillage system.

A composite rate of residue reduction is associated with each tillage implement, and this rate also depends on whether the previous crop is designated as having fragile or nonfragile residue. For example, one tillage pass with a disk would incorporate more of a fragile residue type, like soybeans, than it would of a less fragile crop residue, such as corn. The fragile residue category consists of crops like soybeans which have residue that is easily or quickly decomposed by incorporation and/or weathering. The nonfragile crops (corn and small grains) have residue that decomposes less easily. The resulting residue level immediately after planting is then used in designating the tillage system. The assumption is made that the resulting residue is evenly distributed over the soil surface and, therefore, the percentage of soil surface covered corresponds to the residue value.

Residue estimates

The percentage rate of residue reduction associated with each tillage implement (table 50) was derived from information in agricultural engineering publications (1, 3, 9, 19), university and Cooperative Extension Service reports (5, 7, 8, 17), agronomy and conservation publications (2, 10, 18), and Soil Conservation Service (SCS) bulletins (13, 14, 15).

Rates for implements not covered in the information sources were derived by extrapolation and discussion with some of the authors of the source papers, agricultural engineers, and regional and State agronomists of SCS and Agricultural Research Service. These agronomists also assisted in designating fragile and nonfragile residue types and in estimating starting residue levels of the previous crops.

Table 50.--Percent of starting residue remaining after one pass of selected tillage implements

Machine	Nonfragile 1/	Fragile 1/
	Percent	
Moldboard plow	5	3
Chisel plow	67	40
Subsoil chisel	80	65
Coulter chisel	70	45
Disk plow	20	15
Stubble-mulch plow	85	55
Deep ripper	80	65
Tandem disk	55	40
Tandem,plowing disk	40	30
Offset disk, light duty	50	35
Offset disk, heavy duty	40	30
One-way disk	55	40
Disk-chisel	65	55
Cultipacker	90	90
Paraplow	85	70
Field cultivator, regular	80 85 2/	60 80 2/
Field cultivator, heavy duty	70 80 2/	45 80 2/
DoAll	55	40
Soil finisher	55	40
Row cultivator (shank, rolling)	50	45
Spike-tooth harrow	80	75
Spring-tooth harrow	80	75
Flex-tine tooth harrow	85	80
Cultimulcher	80	65
Finishing harrow	80	75
Multiweeder	80	75
Rail, pipe, log, chain, etc.	95	95
Seed bed conditioner	85	60
Rototiller	45	30
Stalk shredder	100	100
Lister	20	15
Planter, regular	90	85
Planter, air delivery	90	85
Planter, ridge-till	65	40
Planter, no-till	95	90
Planter, lister	20	15

1/ Fragile and nonfragile refer to the type of residue of the previous crop.

2/ The second rate corresponds to when the implement is used after a moldboard plow, disk plow, tandem disk, offset disk, single disk, or one-way disk.

Tillage designations

The methodology is designed to identify three major tillage systems, each containing two subcategories. Conventional tillage is divided into systems using a moldboard plow, and systems not using it. Mulch tillage is divided into high and low residue levels; this tillage system contains the reduced-till definition. The no-till category is divided into ridge-till and no-till; any strip-till system belongs in the no-till category.

Tillage systems are designated according to machine usage and residue levels. First, the no-till category is defined as a system that has no tillage operations before planting. This does allow field passes of implements (such as stalk choppers) which do not incorporate any residue. A ridge-till system is any no-till system in which a crop is planted on a ridge. The first year of a ridge-till system would not be

designated as no-till or ridge-till if other tillage operations were used to build the initial ridges after harvest of the previous crop.

The rest of the tillage systems are split into conventional tillage, which has less than 30 percent of the previous crop residue remaining, and mulch tillage, which has 30 percent or more residue remaining. If a moldboard plow was identified within the machinery complement, that system was designated as conventional tillage with a moldboard plow. If a conventional system did not contain a moldboard plow, it was designated as conventional tillage without a moldboard plow. These systems quite often contain one or more diskings, incorporating 40 to 70 percent of the remaining residue with each pass of a disk. Low residue mulch tillage is identified as having 30 to 50 percent remaining residue; high residue systems have 50 percent or more remaining residue. In this study, the high residue category contained so few observations that the distinction was deleted, and only the single category of mulch tillage was examined.

Special problems and assumptions

The ridge-till category may not strictly adhere to the general definition of being a subcategory of conservation tillage meeting the 30-percent minimum residue criterion indicated in the initial definitions. In this study, usage of only a ridge-till planter on soybean residue could be called ridge-till even though remaining residue was determined to be 26 percent. This was allowed because it was close to the 30-percent break and is commonly accepted as being a ridge-till system. This is an example of the shortcoming of adhering to and interpreting current definitions. Another example is when cultivation to rebuild the ridges is not done until after harvest. This cultivation acts like a tillage operation and usually reduces the previous crop residue to below 30 percent. The steepness of slope upon which ridge-till operations are practiced may also negate the soil conservation objectives of conservation tillage and ridge-till definitions. Ridge-till operations on steeper slopes would require contouring to prevent soil erosion from runoff.

No-till operations (including ridge-till) practiced on previous crops producing small amounts of residue may not meet the remaining residue criterion. These gaps between practice and definition need to be resolved to heighten awareness and interpretation of conservation tillage designations.

For this study, an 85-percent starting residue level was assumed for the previous crops of corn, sorghum, wheat, and alfalfa or other legume hay. Soybeans were assumed to have 65 percent, and crops designated as "other" were assumed to have 75 percent. These estimates included an average winter weathering effect on the residue produced by an average yield level for each crop. Soybeans were assigned to the fragile residue category and the other crops were placed in the nonfragile category.

1987 Corn Production Results

Application of this tillage designation system was performed on corn production data for the 10 major corn-producing States. The source was the Economic Research Service 1987 Cropping Practices Survey conducted by the National Agricultural Statistics Service. The survey is based on a stratifed random sample of corn acres in the 10 States. The data collected included designation of the sequence of implement use for each tillage and planting pass, the time (acres per hour) required for each implement pass, the previous crop grown on that field, and the seed and chemical inputs used for corn production. Therefore, all the necessary elements were available to estimate residual levels immediately after planting.

21 Percent use moldboard plow

Analysis of the data from the 10 major corn-producing States indicate that about 81 percent of the 1987 corn was produced with conventional tillage methods (table 51). Nearly three-fourths of this conventional tillage was done without a moldboard plow.

Use of the plow tended to be higher in Michigan, Minnesota, and Wisconsin. These states have more dairy operations and, therefore, corn is often produced in rotation with hay crops. Use of the moldboard plow was lower in the Corn Belt. Ohio was the exception, reporting use on 43 percent of its acreage. Parts of Ohio (particularly the Maumee River Basin in the northeast) have flat, wet soils with a high clay content. The moldboard plow is used on these soils to allow over-winter weathering, an enhancement in seedbed preparation.

The average percentage of residue remaining on the surface was 2 percent for conventional tillage with a moldboard plow and 14 percent for conventional tillage without it.

Farmers may have felt that they were practicing conservation tillage methods by not using a moldboard plow and/or reducing the number of tillage passes (6, 11). However, many of these farmers are actually practicing conventional tillage without a moldboard plow.

Mulch-till highest in Michigan

About 14 percent of the corn was produced with mulch tillage methods. Michigan reported the highest rate of mulch tillage (22 percent), and Indiana the lowest (4 percent). The average residue remaining was 36 percent for mulch-till systems.

No-till highest in Ohio

A little over 5 percent of the acreage used no-till systems, including ridge-till and strip-till. About 1 percent of the total (one-fifth of the no-till) was designated as ridge-till alone.

Table 51.--Distribution of 1987 corn acreage by tillage system, major producing States

State	Acres harvested	Tillage system: Conventional: With moldboard plow	Without moldboard plow	Mulch-till	No-till
	1000	Percent			
Illinois	9200	[illegible]	71	15	6
Indiana	4750	29	58	4	9
Iowa	10050	12	67	18	3
Michigan	1950	40	31	22	7
Minnesota	5000	32	48	19	*
Missouri	2150	9	81	6	*
Nebraska					
Nonirrigated	2008	*	71	15	*
Irrigated	4192	*	76	14	8
Ohio	3000	43	37	7	13
South Dakota	2700	24	60	14	*
Wisconsin	2850	66	27	6	*
Area	47850	21	60	14	5
Average residue		2	14	36	63

* = Insufficient observations.

Ohio reported the highest incidence of no-till usage (13 percent). Sizeable areas of Ohio have lake plain soils on moderate slopes which respond well to no-till systems.

The no-till category averaged a residue of 63 percent. Within this category, the no-till portion averaged 71 percent and the ridge-till only 34 percent, indicating that ridge-till planters bury a substantial amount of residue.

Only 16 percent of the conventional tillage acreage without a moldboard plow resulted in 20-30 percent residue remaining. At the same time, 84 percent of the mulch-till acreage retained 30-40 percent residue. This indicates that it would take very little change in tillage operations to drop a significant portion of the mulch-till designations into the conventional tillage category. On the other hand, a primary tillage operation (such as disking) would have to be eliminated to raise the residue of a significant portion of the conventional tillage designations to the 30-percent residue level of mulch-till.

Fewer tillage passes

The average number of passes of an implement over the field, including planting, is illustrated in table 52. This does not include cultivation for weed control during the growing season. By definition, the no-till system has about one pass of an implement—the planter. An extra implement pass by a stalk chopper occurs mainly in the high yield areas, such as irrigated corn acreage in Nebraska. Mulch-till systems average one and a half more passes than no-till. Conventional tillage systems average about four passes when a

Table 52.--Average number of implement passes by tillage system for 1987 corn acreage, major producing States

State	Tillage system: Conventional: With moldboard plow	Without moldboard plow	Mulch-till	No-till
	Passes			
Illinois	4.2	3.7	2.6	1.0
Indiana	3.9	3.5	3.0	1.0
Iowa	4.2	3.4	2.5	1.1
Michigan	4.0	3.7	3.1	1.0
Minnesota	4.1	3.7	2.7	*
Missouri	4.7	3.8	3.0	*
Nebraska				
Nonirrigated	*	3.2	2.0	*
Irrigated	*	3.5	2.8	1.6
Ohio	4.0	3.6	2.6	1.0
South Dakota	4.0	3.7	2.9	*
Wisconsin	4.3	3.8	2.8	*
Area	4.1	3.6	2.7	1.1

* = Insufficient observations.

moldboard plow is used and about three and a half when it is not. This is roughly the same as was reported for 1985 conventional tillage corn (12).

Less time with conservation tillage

The average number of hours per acre required for tillage and planting was .16 for no-till, .29 for mulch-till, .44 for conventional tillage without the moldboard plow, and .79 for conventional tillage with the plow (table 53). The number of hours is also related to equipment type, size, and speed. Compared to no-till, the conventional system with a moldboard plow requires about five times as many hours per acre. However, it had only four times the number of passes. This reflects the slower speed usually associated with use of a moldboard plow.

Limitations

Other factors must be considered in determining the percentage of soil surface covered by previous crop residue. The incorporation rate of an implement also varies according to its speed and attachments (for example, shovels, blades, or sweeps). The soil type affects speed and mixing (incorporation). The timing of an implement pass (fall vs. spring and the time between passes) also has an effect. Incorporation also depends on whether the residue is standing (stalks) or flat (cut stems and leaves). If residue is more weathered (for example, if it is flat, more time has elapsed since the last implement pass, and/or the acreage was tilled in spring instead of fall), more of it will be incorporated. These factors

Table 53.--Average hours per acre by tillage system for 1987 corn acreage, major producing States

State	Tillage system			
	Conventional			
	With moldboard plow	Without moldboard plow	Mulch-till	No-till
	Hours			
Illinois	.55	.40	.21	.13
Indiana	.65	.50	.39	.18
Iowa	.77	.41	.26	.17
Michigan	.81	.58	.42	.14
Minnesota	.75	.47	.31	*
Missouri	1.10	.49	.50	*
Nebraska				
Nonirrigated	*	.42	.26	*
Irrigated	*	.39	.31	.16
Ohio	.84	.56	.37	.21
South Dakota	.72	.41	.35	*
Wisconsin	.99	.69	.37	*
Area	.79	.44	.29	.16

* = Insufficient observations.

were beyond the scope of this study and its survey data, and account for the development of an average or composite rate for each designated implement. These relationships are being studied by various disciplines and should be considered in revising estimates of residue incorporation.

Extensions of this study will examine the relationship between tillage systems and seeding rates, fertilizer and pesticide application rates, and yields. These factors will be studied for different crops and timeframes as data become available.

References

1. Burr, Charles A., Dickey, Elbert C., and Shelton, David P. "Tillage System, Row Spacing, and Variety Influences on Soybean Residue Cover." 87-1006. American Society of Agricultural Engineers, 1987.

2. Colvin, Tom S. and Gilley, John E. "Crop Residue: Soil Erosion Combatant," *Crops and Soils Magazine*. April-May 1987.

3. Colvin, T.S., and others. "Tillage Implement Effects on Corn and Soybean Residue," Transactions of the American Society of Agricultural Engineers. Vol. 29 (1), (January-February 1986).

4. Conservation Technology Information Center. National Survey of Conservation Tillage Practices. West Lafayette, Indiana.

5. Dickey, Elbert, Harlan, Phillip, and Vokal, Don. "Crop Residue Management for Water Erosion Control." G81-554. University of Nebraska-Lincoln, Cooperative Extension Service, Institute of Agriculture and Natural Resources, April 1981.

6. Dickey, Elbert C., and others. "Conservation Tillage: Perceived and Actual Use," *Journal of Soil and Water Conservation*, 42 (6), (1987), 431-434.

7. Dickey, Elbert C., Jasa, Paul J. and Shelton, David P. "Estimating Residue Cover." G86-793. University of Nebraska-Lincoln, Cooperative Extension Service, Institute of Agriculture and Natural Resources, June 1986.

8. Dickey, Elbert C., Shelton, David P., and Jasa, Paul J. "Residue Management for Soil Erosion Control." G81-554. University of Nebraska-Lincoln, Cooperative Extension Service, Institute of Agriculture and Natural Resources, April 1986.

9. Gregory, James M. "Cover Prediction with Various Amounts and Types of Crop Residue," Transactions of the American Society of Agricultural Engineers. 1982.

10. Johnson, Richard R. "Soil Engaging Tool Effects on Surface Residue and Roughness with Chisel-type Implements," *Soil Science Society of America Journal*, 52 (1988), 237-243.

11. Nowak, P.J., and Korsching, P.F. "Conservation Tillage: Revolutionary or Evolutionary?," *Journal of Soil and Water Conservation*, 40 (2), (1985), 199-201.

12. Szmedra, Philip I., and Delvo, Herman W. "1985 Tillage Practices—Corn and Soybeans," *Agricultural Resources: Inputs Situation and Outlook Report*. AR-3. August 1986.

13. USDA, Soil Conservation Service, "Estimating Crop Residue." NE Leaflet No. 3. Lincoln, Nebraska.

14. USDA, Soil Conservation Service, Technical Guide Information from the States of North Dakota, Michigan, Iowa, Kansas, Minnesota, Missouri, South Dakota, Wisconsin, Illinois, and Idaho.

15. USDA, Soil Conservation Service. "Using Crop Residue to Help Control Wind and Water Erosion." Columbia, Missouri. February 1986.

16. USDA, Economic Research Service, Farm Costs and Returns Survey.

17. Wessels, Frans. "Crop and Tillage Effects on Residue Cover." Pullman, Washington: USDA-Agricultural Research Service, Agricultural Engineering Department, Washington State University. July 15, 1988.

18. Williams, J.R., Renard, K.G., and Dyke, P.T. "EPIC: A New Method for Assessing Erosion's Effect on Soil Productivity," *Journal of Soil and Water Conservation*, 38 (1983), 381-383.

19. Williams, J.R., Jones, C.A., and Dyke, P.T. "A Modeling Approach to Determining the Relationship Between Erosion and Soil Productivity," Transactions of the American Society of Agricultural Engineers, 27 (1984), 129-144.

FARM LABOR INPUTS

by

James Duffield and Robert Coltrane

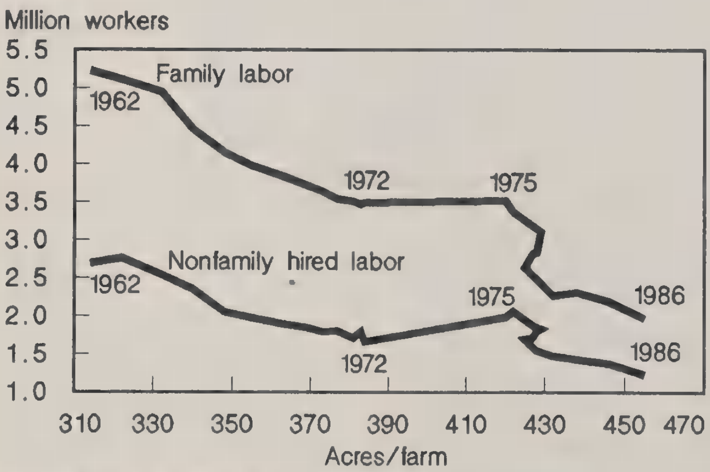
ABSTRACT: Labor-saving technologies and higher nonfarm wages reduced total labor input on U.S. farms from about 19.3 billion hours in 1950 to 5.5 billion hours in 1986. But farm wages have risen at a greater rate than the price of other farm inputs, such as agricultural chemicals, making them cheap substitutes for labor. Nevertheless, labor expenditures still make up a significant portion of total cash operating expenses, accounting for 10.7 percent in 1986. The large declines in farm labor had tapered off by the 1980's when the production of many commodities had become completely mechanized. However, the harvesting of most fresh fruit and vegetables still is not mechanized and requires large amounts of seasonal labor. The Immigration Reform and Control Act of 1986 (IRCA) has the potential of significantly reducing illegal immigration, historically a main source of seasonal farm labor. The IRCA will have the greatest effect on farmers who depend upon large amounts of labor. Data from the 1986 Farm Costs and Returns Survey show that large farms, farms specializing in vegetables, fruit and tree nuts, and horticultural specialty crops, and farms in the Pacific and Southeast may be most affected.

KEYWORDS: Labor, farm wage, immigration reform, input substitution, mechanization.

Introduction

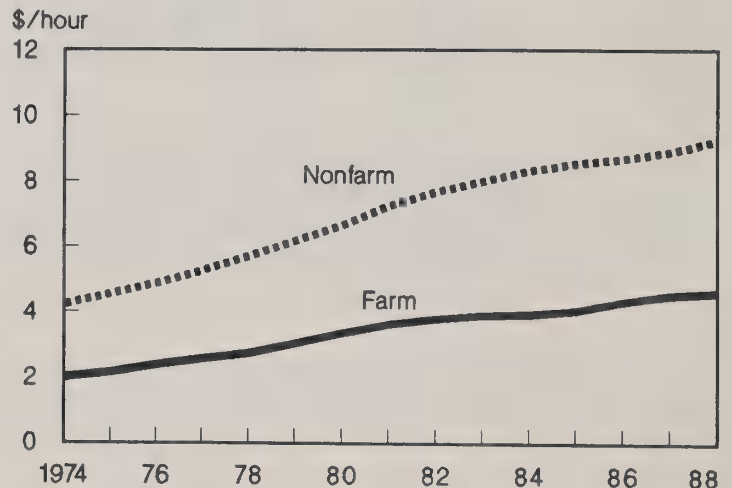
During the last several decades significant changes in labor use have occurred on U.S. farms. Total labor input declined from about 19.3 billion hours in 1950 to 5.5 billion hours in 1986. Development of labor-saving technologies, the substitution of relatively less expensive inputs for labor, and higher wages paid in the U.S. nonfarm sector are largely responsible for reducing farm employment levels over the long term. Also, total farm employment declined as farm numbers decreased and average farm size increased. Figure 1 shows the negative relationship between the number of workers (family and nonfamily hired) and large scale farming from 1962 to 1986.

Figure 1
Number of Workers and Farm Size



Number of workers reported in July.
USDA'S definition of a farm changed in 1975. Source: (3,5).

Figue 2
Farm and Nonfarm Wages



Wages reported in July. Nonsupervisory occupations. Sources: (3,6).

The nonfarm wage consistently stayed above the farm wage from 1974 to 1988 (figure 2). While a number of factors, including the supply of workers, affect the farm wage rate, the exodus of workers from the agricultural sector did not raise farm wages relative to the nonfarm wage.

Since the farm work force has been comprised of U.S. workers and illegal immigrants, the Immigration Reform and Control Act of 1986 (IRCA) could significantly reduce an

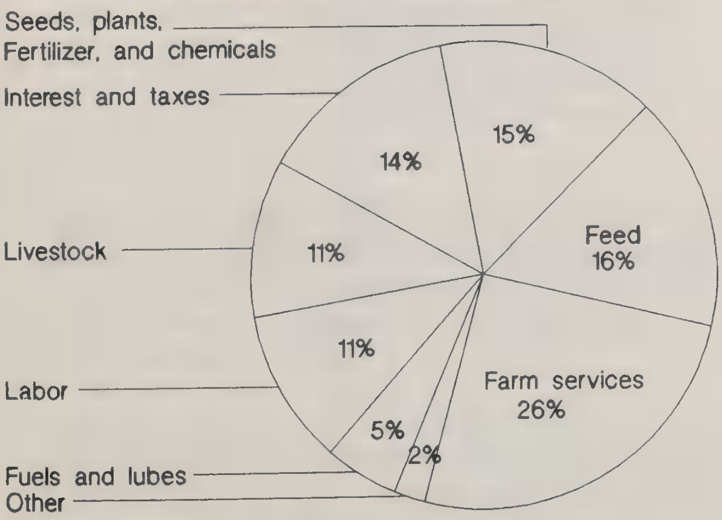
important source of farm labor by controlling illegal immigration. However, IRCA provides the mechanism for replacing some illegal foreign workers with legal ones. To the extent that impacts from IRCA are significant, they will most likely have the greatest effect on farm producers who depend upon large amounts of seasonal labor. The effect that further decreases in the supply of farm labor will have on the farm wage depends on relative input and product prices, the substitutability between labor and other inputs, and changes in farm technology.

Review

Since the 1940's, farms have become fewer and larger. The decline in farms reduced the number of farm operators and unpaid family workers more than it has the number of nonfamily workers. The result is that nonfamily labor has been substituted for family labor over time. Aggregate declines in farm labor masks the fact that farm enlargement has increased the average number of hired workers needed on the bigger farms. In addition, the need for nonfamily hired labor increased as improved off-farm employment opportunities reduced the availability of paid family members. However, this trend of substituting nonfamily labor for family labor appears to be leveling off. Total hours worked on U.S. farms declined slightly from 1982 to 1986, and the proportion of total hours worked in agriculture attributed to hired workers changed little (a constant 34 percent of all hours over the 5 years) (3).

Over the past several decades, farm wage rates rose at a much greater rate than the price of fertilizers and other agrichemical products. As a result, agri-chemicals became relatively less expensive, making them cheap substitutes for labor and other competitive inputs. However, labor expenditures still make up a significant portion of total cash operating expenses. From 1982 to 1986, farm labor expenses remained stable relative to total cash operating expenses (4).

Figure 3
1986 Cash Operating Expenditures



Source: (1986 FCRS)

The 1986 Farm Costs and Returns Survey (FCRS) reported 813,000 farms with labor expenses of $9.9 billion and almost 84 percent of total farm sales. Labor expenditures were larger than the amounts spent by farmers on commercial fertilizer, other chemical products, or farm machinery, and were only slightly less than interest costs. Labor expenditures comprised 10.7 percent of total operating expenses in 1986 (figure 3).

There has been an increasing amount of input substitution, such as herbicides and machinery, for labor in the production of row crops. By 1980, however, the large declines in farm labor observed in the 1950's and 1960's had tapered off with the mechanized production of many commodities and about 95 percent of corn, soybean and cotton acres were treated with herbicides. Even among many specialty crops, hand weeding has been replaced with chemical weed control. But the harvesting of some crops, including sugarcane, tobacco, and most fresh fruits and vegetables, has benefited very little from the general mechanization trend, and large quantities of seasonal labor are still required. Several commodities, including citrus fruits, fresh market apples, lettuce, broccoli, and cauliflower are still totally harvested by hand. Mechanical harvesting of many of these crops would require additional research and development, and in some cases appreciable farmer investment in replanting orchards and groves to dwarf and semi-dwarf varieties (2). Mechanical harvesting of some crops has not been adopted because the product is particularly susceptible to damage or the acreage per farm used in growing the crop is too small for a specialized machine, designed for large-scale production, to be cost effective (1). For a small number of crops (watermelons, strawberries, and nectarines), mechanical harvesting is not yet conceivable. Production of those fresh fruits and vegetables, where harvesting remains unmechanized, is highly dependent on migratory labor, including immigrants. As long as such a large labor force is available, adoption of mechanization over the next few years will likely be insignificant. However, Government policies, such as the IRCA, could accelerate the adoption of labor-saving technology for some crops, such as lettuce, where basic machine design already exists.

Farms with Agricultural Workers

Eighty-three percent of the farmers reporting labor expenditures in the 1986 FCRS hired either family or nonfamily workers. Just 6.8 percent contracted out all their paid labor requirements, and the remaining 9.8 percent employed a combination of hired and contract labor. A large number of farms (74.1 percent) hired nonfamily labor only. Less than 4 percent of them only hired family labor, and the remaining 5.4 percent hired a combination of hired family and nonfamily labor. Nonfamily hired labor accounted for 86.4 percent of all labor expenditures. Wage payments for the services of contract workers amounted to 8.6 percent and hired family accounted for only 5 percent (table 54).

The importance of labor differs by farm type, size, and location as well as type of worker. Vegetable farms, fruit and tree nut farms, and nurseries and greenhouses combined accounted for only 9.6 percent of all farms with hired and contract labor, but they accounted for almost 38.5 percent of labor expenses. All other crop farms reported 24.4 percent of labor expenses, and all livestock operations had 37.1 percent (table 55).

Per farm spending for labor varied greatly by farm type. Average labor expenses were highest on vegetable farms at about $85,000, and lowest on beef, hog, and sheep farms at around $5,100. The high per farm outlay shown in table 55 on vegetable farms, fruit and tree nut farms, and in nurseries and greenhouses reflects large requirements for seasonal hand labor, but the large average expenditure on highly mechanized cotton farms is due more to size of operation. In contrast to these farm types, labor expenses per cash grain operation were about $6,500.

The importance of labor expenditures, measured by the proportion of labor expenses to all cash operating expenses,

Table 54-- U.S. farms employing labor, 1986

Type of labor	Farms: Number	Farms: Share	Labor expenditures: Dollars	Labor expenditures: Share
	1,000	Percent	Millions	Percent
Hired labor only	678.9	83.4	6,532.7	65.9
Hired family only	31.5	3.9	134.8	1.4
Hired nonfamily only	603.1	74.1	5,740.8	57.9
Hired family and nonfamily	44.3	5.4	657.1	6.6
Hired family	na	na	250.2	2.5
Hired nonfamily	na	na	406.9	4.1
Contract labor only	55.1	6.8	154.6	1.6
Hired and contract labor	79.4	9.8	3,224.2	32.5
Hired nonfamily	na	na	2,425.6	24.4
Hired family	na	na	106.3	1.1
Contract	na	na	692.3	7.0
All farms with labor expenditures	813.4	100.0	9,911.5	100.0

na = Not applicable.

Source: (1986 FCRS).

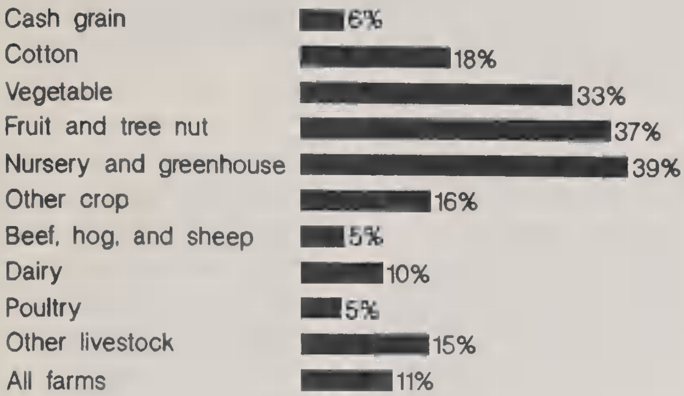
Table 55.--Labor expenditures by type of farm, 1986

Type of farm	Farms with labor expenditures	Total labor expenditures 1/: Share by farm type	Total labor expenditures 1/: Average per farm
	1,000	Percent	Dollars
Cash grain	187.6	12.3	6,509
Cotton	10.1	3.8	37,001
Vegetable	16.4	14.0	84,985
Fruit and tree nut	43.8	16.0	36,128
Nursery and greenhouse	18.0	8.5	46,825
Other crop	91.2	8.3	9,072
Beef, hog and sheep	285.0	14.7	5,092
Dairy	121.5	16.5	13,408
Poultry	15.3	2.3	14,959
Other livestock	24.5	3.6	14,768
All farms	813.4	100.0	12,187

1/ See table 54, column 3.

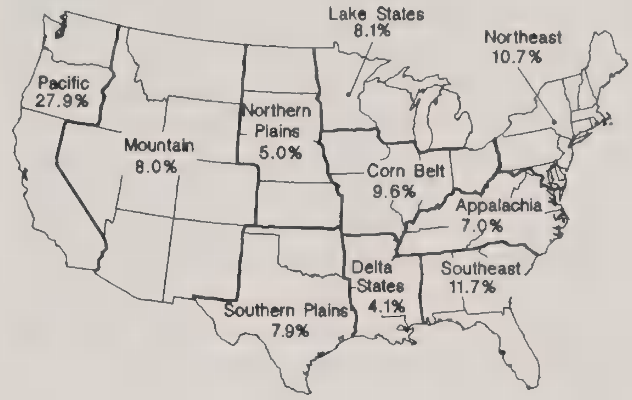
Source: (1986 FCRS).

Figure 4
Labor's Share of Cash Operating Expenses by Type of Farm, 1986



Source: (1986 FCRS).

Figure 5
Regional Share of U.S. Farm Labor Expenses, 1986



Source: (1986 FCRS).

also varies by farm type. This proportion varied substantially in 1986 from just under 5 percent for poultry farms to almost 40 percent for nurseries and greenhouses (figure 4).

Collectively, fruit and tree nut operations were the biggest users of contract labor, accounting for over 43 percent of the contract labor expenses reported. Cash grain farms used more hired family labor than any other farm type, accounting for over 34 percent of hired family labor expenditures. These farms, plus beef, hog, sheep, and dairy, accounted for about 80 percent of all hired family expenses.

Along with type of commodity produced, farm size has a major influence on labor expenditures. About 27,000 farms with annual sales of $500,000 or more reported over 46 percent of all farm labor expenditures in 1986. Farms with sales of $100,000 to $499,999 had an additional 36.7 percent of the labor expenditures reported in the survey, while farms with sales less than $100,000 had only about 17 percent of the labor expenditures.

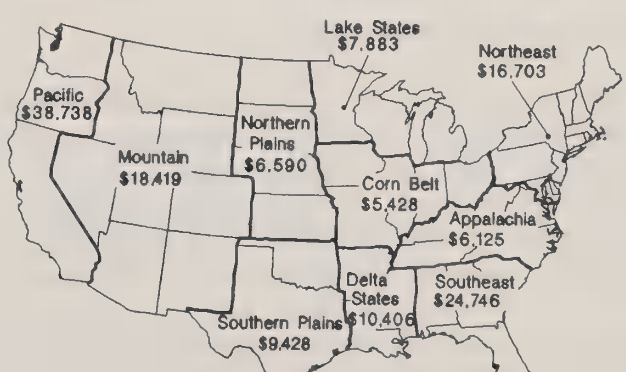
Vegetable farms, fruit and tree nut farms, and nurseries and greenhouses dominate the $500,000-or-more sales class. These farms combined accounted for over 50 percent of labor expenditures in this sales class and the largest expenditure per farm.

Farm labor expenditures made up a larger proportion of all cash operating expenditures on larger farms than on smaller ones. The proportion increased from 6 percent for farms in the less-than-$100,000 class to over 18 percent in the $500,000-and-over sales class.

Hired and contract labor is clustered regionally (figure 5). Of the 10 USDA farm production regions, three accounted for about 50 percent of U.S. total farm labor expenditures in 1986: the Pacific (27.9 percent), the Southeast (11.7 percent), and the Northeast (10.7 percent). In contrast, the combined labor expenditures for the Northern Plains, Appalachia, and the Delta Region only amounted to about 16 percent of total farm labor expenditures. Farms in the Pacific region also had the Nation's highest average labor expenditure per farm, which was more than twice that of any other region except the Southeast (figure 6).

Differences in regional labor expenditures are a function of the type of crops grown in each region. High labor expenditures in the Pacific region are related to the labor intensive crops grown there, e.g., vegetables, fruit and tree nuts, and poultry. The Southeast, especially Florida, also are major suppliers of several labor intensive vegetables, including sweet corn, watermelon, fresh tomatoes, and sweet pepper. Dairies and nursery and greenhouse operations are largely responsible for the high labor expenses in the Northeast region.

Figure 6
Per Farm Labor Expenses, 1986



Source: (1986 FCRS).

Implications of IRCA

The IRCA attempts to prevent illegal aliens from working on U.S. farms by imposing fines and prison sentences on employers who hire them. However, the IRCA granted legal U.S. residence status to many qualifying aliens and it established legal avenues for farmers to employ foreign workers under the H-2A Temporary Foreign Worker Program and the Special Agricultural Worker Program. About 1.3 million aliens applied for legal residence under the Special Agricultural Worker (SAW) Program. To qualify, aliens had to demonstrate that they worked at least 90 days in the year ending May 1, 1986 in crops included in the SAW program (no livestock or livestock products are included). Aliens had until November 30, 1988 to apply for legalization under this Program. Also, if the newly legalized SAW's leave employment in these crops, IRCA provides for the replacement of a proportion of such workers with additional foreign workers for the next four years, starting in 1989.

Any major impact of the IRCA on the farm labor supply will not begin to be felt until the 1989 or later production seasons. If the newly legalized foreign workers leave agriculture causing a significant reduction in paid farmworkers, adjustments to a smaller labor supply will be felt unevenly among producers who depend on hired labor. Labor expenditure data in this report has shown differences in paid labor use by farm type, size, and region. Farms using the most paid labor per operation produce vegetables, fruit and tree nuts, and horticultural specialty crops. Their crops are the least mechanized of all crops, and most jobs on these farms are seasonal, the kind of jobs that many undocumented workers have taken in previous years. Beef, hog, and sheep operations used the least amount of paid labor. Large farms will feel the impact of immigration reform more than smaller ones because their labor requirements greatly exceed the amounts available from operator and family workers. Because labor intensive farm types and large farms are not evenly distributed throughout the country, impacts on the supply of labor will be concentrated regionally. Farms in three regions—Pacific, Southeast, and Northeast—accounted for about half of all farm labor expenses in 1986.

Need For Further Research

Knowledge of input substitution relationships is important in projecting the impact of the IRCA on producers of labor intensive crops. There are important distinctions between seasonal hired labor, year-around hired labor, and family/operator labor. These different types of workers respond differently to changing economic conditions. Also, the substitution of capital for labor varies by type of worker. For example, some researchers think that capital and seasonal farm labor are substitutes while capital and year-around labor act more like complements. However, most input demand studies have lumped labor types together into a single category. In the long term, the impact that the IRCA has on the farm labor supply and wage rates will depend greatly on the producers' ability to replace seasonal labor with other types of labor or capital. Research identifying the diversity of farm workers would be helpful in estimating the impacts of IRCA on farm labor supply, wages, and other agricultural production factors.

Producers have become more dependent on nonfamily hired labor and the substitution of capital for labor has leveled off. Therefore, a reduction in the supply of immigrant workers could increase the farm wage rate above the long-term upward trend. The effect of such wage increases on net farm income depends on the producers' ability to substitute capital for labor and pass cost increases on to the consumer. This is directly tied to the competitive position of U.S. producers vs. those foreign producers who sell labor intensive crops to U.S. consumers. A price increase on U.S. agricultural commodities, triggered by higher wages, could reduce the market share of U.S. producers relative to foreign producers. Research is needed to estimate changes in U.S. farm labor costs due to IRCA and assess the effects of these costs on the competitive position of U.S. producers vis-a-vis foreign producers in supplying vegetables, fruit and tree nuts, and other labor-intensive commodities to U.S markets.

References

1. American Society of Agricultural Engineers. "Status of Harvest Mechanization of Horticultural Crops," March 1983. ISBN 0916150-50X. 2950 Niles Road, St Joseph, MI 49085.

2. Brown, G.K. "Fruit and Vegetable Mechanization", *Migrant Labor in Agriculture-An International Comparison*, Edited by Philip L. Martin. Papers Presented at a Conference Sponsored by the Giannini Foundation of Agricultural Economics, University of California and the German Marshall Fund of the United States, Washington D.C., May 23-25, 1984.

3. USDA. Farm Labor (1962-1986). Agricultural Statistics Board, National Agricultural Statistics Service. Washington, D.C.

4. USDA. Farm Production Expenditures, 1986 Summary (and earlier issues). National Agricultural Statistics Service, Agricultural Statistics Board. Washington, D.C.

5. U.S. Department of Commerce, Bureau of the Census. Statistical Abstract of the United States, 1988 (and earlier issues). U.S. Government Printing Office, Washington D.C.

6. U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings, August 1988 (and earlier monthly issues). Washington, D.C.

Appendix table 1.--U.S. fertilizer imports: Declared value of selected materials

Material	Fertilizer year 1986/87	Fertilizer year 1987/88	July - November 1987	July - November 1988
	Million dollars			
Nitrogen:				
Anhydrous ammonia	230	252	96	126
Urea	249	192	49	67
Ammonium nitrate	33	19	5	7
Ammonium sulfate	20	19	5	8
Sodium nitrate	11	12	3	5
Calcium nitrate	12	16	5	5
Nitrogen solutions	30	35	7	12
Other	22	18	5	7
Total 1/	607	563	173	237
Phosphate:				
Ammonium phosphates	22	20	9	7
Crude phosphates	18	21	10	11
Phosphoric acid	*	*	*	*
Normal and triple superphosphate	3	20	4	*
Other	*	*	*	*
Total 1/	44	61	22	18
Potash:				
Potassium chloride	328	576	173	208
Potassium sulfate	9	13	3	5
Potassium nitrate 2/	8	11	3	5
Total 1/	345	600	179	218
Mixed fertilizers	20	18	2	3
Total 1/	1,016	1,242	377	476

* = Less than $500,000.

1/ Totals may not add due to rounding. 2/ Includes potassium sodium nitrate.

Source: (7).

Appendix table 2.--Plant nutrient use by State for years ending June 30 1/

State, region	1987 N	1987 P205	1987 K20	1988 N	1988 P205	1988 K20
	1,000 nutrient tons					
Maine	13	10	11	11	9	10
New Hampshire	2	1	2	2	1	2
Vermont	5	4	6	4	3	6
Massachusetts	11	5	[illegible]	12	6	8
Rhode Island	2	1	1	2	1	1
Connecticut	7	4	5	6	2	3
New York	85	66	98	76	61	90
New Jersey	23	14	17	25	13	16
Pennsylvania	75	55	47	46	35	29
Delaware	17	6	14	26	6	12
Maryland	52	37	44	53	38	45
NORTHEAST..........	290	203	253	264	174	222
Michigan	237	132	233	233	126	222
Wisconsin	254	132	356	244	130	309
Minnesota	573	228	323	576	249	321
LAKE STATES.........	1,063	493	912	1,053	505	852
Ohio	373	179	308	333	175	325
Indiana	491	265	428	434	227	384
Illinois	841	374	618	938	394	693
Iowa	853	288	440	921	338	480
Missouri	332	150	226	364	169	244
CORN BELT..........	2,889	1,255	2,020	2,991	1,303	2,126
North Dakota	318	139	27	284	139	30
South Dakota	178	67	15	196	79	20
Nebraska	674	129	31	684	126	31
Kansas	528	132	27	573	142	41
NORTHERN PLAINS.....	1,698	468	100	1,737	486	121
Virginia	78	53	69	76	56	74
West Virginia	11	12	11	7	8	[illegible]
North Carolina	193	91	156	181	91	163
Kentucky	175	114	136	177	116	137
Tennessee	146	108	135	156	107	131
APPALACHIA..........	603	378	508	598	378	513
South Carolina	72	30	60	78	32	67
Georgia	193	85	132	191	95	146
Florida	280	129	261	229	95	246
Alabama	120	55	71	116	58	73
SOUTHEAST..........	665	300	524	614	281	532
Mississippi	152	39	52	127	40	55
Arkansas	206	52	78	219	57	88
Louisiana	153	42	55	148	50	63
DELTA STATES........	511	132	184	494	146	206
Oklahoma	271	95	28	306	95	34
Texas	750	210	105	898	229	107
SOUTHERN PLAINS.....	1,022	305	133	1,204	324	140
Montana	101	60	11	98	59	13
Idaho	158	65	14	159	64	14
Wyoming	15	4	0	14	3	0
Colorada	154	37	10	167	49	11
New Mexico	30	9	5	32	11	4
Arizona	85	24	2	84	28	2
Utah	25	12	2	26	12	2
Nevada	5	6	0	3	2	0
MOUNTAIN...........	573	218	44	583	228	46
Washington	203	47	31	197	51	39
Oregon	126	34	28	131	37	29
California	535	159	70	577	183	85
PACIFIC............	863	241	128	905	271	153
48 States and D.C....	10,178	3,993	4,806	10,442	4,096	4,912
Alaska	2	1	1	3	1	1
Hawaii	16	9	17	17	9	18
Puerto Rico	13	6	12	13	5	12
U.S. TOTAL.........	10,210	4,008	4,836	10,475	4,112	4,943

1/ Totals may not add due to rounding.

Source: (3).

RELIABILITY OF ESTIMATES

Fertilizer application rates reported in Appendix tables 3 through 6 are based on farm surveys taken during June, July, and August. These surveys are subject to sampling and nonsampling errors that are common to all surveys.

To assist users in evaluating the reliability of the fertilizer application rate estimates, a coefficient of variation was calculated. The coefficient of variation (CV) is computed by dividing the standard error of the estimate by its mean, and is expressed as a percent. One * indicates that the CV is greater than 10 percent, and two **'s indicate that the CV is greater than 20 percent.

For example, the 10-State average nitrogen application rate per acre for corn was estimated at 137 pounds with a CV of 1 percent. This means that chances are 2 out of 3 that nitrogen use per acre will not be greater than 138.6 or less than 135.4 pounds. A higher CV indicates greater variability in the estimate. Arkansas' P205 application rate per acre for cotton was estimated at 44 pounds with a CV of 10 percent. Chances are 2 out of 3 that the P205 use per acre will not be greater than 48.4 pounds nor less than 39.6 pounds. In the case of Missouri's per acre nitrogen use on soybeans, the mean was estimated at 24 pounds with a CV of 35 percent, which translates into a range for the true mean of between 15.6 and 32.4 pounds two times out of three.

Appendix table 3.--Fertilizer use on corn for grain, 1988

State	Acres planted	Fields in survey	Acres receiving: Any ferti-lizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	1,000	No.	Percent				Pounds			Percent		
Illinois	9,900	240	100	100	89	89	163	87	109	78	1	21
Indiana	5,200	191	97	97	92	85	146	71	113	58	2	41
Iowa	11,300	218	99	99	91	87	139	57	78	80	3	17
Michigan	2,100	97	100	100	95	95	129	61	103	51	0	49
Minnesota	5,700	189	96	96	90	87	118	52	65	82	0	18
Missouri	2,200	125	98	98	85	87	132	58	69	85	2	12
Nebraska	6,900	207	99	99	72	36	142	38	22*	69	5	26
Ohio	3,300	167	99	99	96	93	158	80	111	51	1	48
South Dakota	3,150	123	75	75	57	30	80	38	26*	86	1	13
Wisconsin	3,450	152	99	98	95	97	87	56	77	72	0	28
Area	53,200	1,709	97	97	87	78	137	63	85	73	2	25

* = CV greater than 10 percent.

Appendix table 4.--Fertilizer use on cotton, 1988

State	Acres planted	Fields in survey	Acres receiving: Any ferti-lizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	1,000	No.	Percent				Pounds			Percent		
Arizona	340	90	91	90	58	7	144	59	14	21	30	49
Arkansas	680	95	100	99	71	75	79	44*	58	43	6	51
California	1,350	227	94	93	36	16	124	45	39*	52	21	26
Louisiana	700	94	94	94	59	65	88	51	58	34	28	38
Mississippi	1,230	167	98	98	50	56	110	49	59	30	12	57
Texas	5,400	508	68	68	56	22	45	38	13	62	18	20
Area	9,700	1,181	80	80	54	32	78	42	39	50	18	32

* = CV greater than 10 percent.

Appendix table 5.--Fertilizer use on soybeans, 1988

State	Acres planted	Fields in survey	Acres receiving: Any ferti-lizer	Acres receiving: N	Acres receiving: P205	Acres receiving: K20	Application rates: N	Application rates: P205	Application rates: K20	Proportion fertilized: At or before seeding	Proportion fertilized: After seeding	Proportion fertilized: Both
	1,000	No.	Percent				Pounds			Percent		
Arkansas	3,250	130	24	10	21	22	28*	45*	62*	97	3	0
Georgia	900	82	79	49	76	79	15	36	76	98	2	0
Illinois	8,800	187	35	9	25	34	20*	67	101	100	0	0
Indiana	4,300	116	51	31	41	49	18**	40	78	98	0	2
Iowa	7,950	157	13	9	10	12	24**	33*	65*	100	0	0
Kentucky	980	92	53	34	50	47	39**	69*	80	96	2	2
Louisiana	1,800	111	30	9	30	30	18**	41	62	100	0	0
Minnesota	4,900	109	23	16	20	20	21**	57*	51*	96	4	0
Mississippi	2,400	112	23	9	18	21	37**	41	68	100	0	0
Missouri	4,300	145	28	12	21	27	24**	49*	74	95	5	0
Nebraska	2,400	79	14	14	11	8	32**	24*	16**	91	9	0
North Carolina	1,470	96	72	54	63	72	14*	34	72	97	3	0
Ohio	3,900	127	48	20	35	46	17**	46*	102	98	0	2
Tennessee	1,400	94	57	30	52	55	34*	44	61	98	2	0
Area	48,750	1,637	32	16	26	31	22	48	79	98	1	#

* = CV greater than 10 percent. ** = CV greater than 20 percent.
# = Less than 0.5 percent.

Appendix table 6.--Fertilizer use on wheat, 1988

State	Acres for harvest	Fields in survey	Acres receiving: Any ferti-lizer	N	P205	K20	Application rates: N	P205	K20	Proportion fertilized: At or before seeding	After seeding	Both
	1,000	No.	Percent				Pounds			Percent		
						Winter wheat						
Arkansas	1,050	72	100	100	38	35	94	37*	43*	3	73	25
California	440	63	86	86	27	13	98	55	#	63	11	26
Colorado	2,350	87	63	62	13	2	43	17*	#	90	8	2
Idaho	790	88	91	91	60	6	101	33	19**	35	25	40
Illinois	1,220	64	99	98	92	80	98	79	95	18	5	77
Indiana	700	61	96	96	85	85	72	58	76	16	10	74
Kansas	9,400	246	89	89	50	4	53	34	31**	65	8	27
Missouri	1,550	74	99	99	77	83	90	52	69	31	21	48
Montana	2,100	96	80	79	76	7	45	30	25	82	5	13
Nebraska	2,000	95	73	73	33	2	43	29	#	60	22	19
Ohio	920	69	100	100	96	96	70	60	76	25	13	62
Oklahoma	4,800	147	86	86	44	13	70	30	13*	43	9	48
Oregon	660	78	99	99	22	14	73	34*	35**	70	15	14
Texas	3,100	151	70	70	45	9	80	39	24*	68	13	19
Washington	1,750	149	100	100	26	6	69	24	32**	87	3	10
Area	32,830	1,540	86	86	48	18	66	40	59	56	13	31
						Spring wheat						
Idaho	380	54	87	87	43	6	97	46	#	85	2	13
Minnesota	2,000	72	100	100	93	67	103	41*	38*	92	1	7
Montana	1,500	63	57	56	54	3	25*	21	#	97	0	3
North Dakota	4,600	105	79	79	73	12	50	30	17*	99	0	1
South Dakota	1,300	37	73	73	57	3	42	25*	#	100	0	0
Area	9,780	331	79	79	71	21	62	32	31*	96	0	3
						Durum wheat						
North Dakota	2,500	125	66	66	55	3	39	27	#	98	1	1
						All wheat 1/						
Arkansas	1,050	72	100	100	38	35	94	37*	43*	3	73	25
California	440	63	86	86	27	13	98	55	#	63	11	26
Colorado	2,350	87	63	62	13	2	43	17*	#	90	8	2
Idaho	1,170	141	90	90	54	6	100	36	21**	46	19	36
Illinois	1,220	64	99	98	92	80	98	79	95	18	5	77
Indiana	700	61	96	96	85	85	72	58	76	16	10	74
Kansas	9,400	246	89	89	50	4	53	34	31**	65	8	27
Minnesota	2,000	64	100	100	93	67	103	41*	38*	98	2	0
Missouri	1,550	74	99	99	77	83	90	52	69	31	21	48
Montana	3,600	163	70	69	67	6	38	27	22**	86	5	8
Nebraska	2,000	95	73	73	33	2	43	29	#	60	22	19
North Dakota	7,100	240	75	75	67	9	47	29	16*	97	0	2
Ohio	920	69	100	100	96	96	70	60	76	25	13	62
Oklahoma	4,800	147	86	86	44	13	70	30	13*	43	9	48
Oregon	660	78	99	99	22	14	73	34*	35**	70	15	14
South Dakota	1,300	57	73	73	57	3	42	25*	#	97	3	0
Texas	3,100	151	70	70	45	9	80	39	24*	68	13	19
Washington	1,750	149	100	100	26	6	69	24*	32**	87	3	10
Area	45,110	2,021	83	83	53	18	64	37	52	66	10	24

* = CV greater than 10 percent. ** = CV greater than 20 percent.
# = Insufficient data.

1/ Does not include winter wheat in MN, ND, and SD; spring wheat in CA, CO, and WA; and durum wheat in MN, MT, and SD.

Appendix table 7.--Projected world supply-demand balances of plant nutrients 1/

World regions	Nitrogen		Phosphate		Potash	
	1988	1993	1988	1993	1988	1993
	Million metric tons					
Developed market economies:						
Supply	21.46	21.74	17.47	18.47	16.43	16.72
Demand	23.46	23.36	11.48	12.06	11.27	11.81
Balance	-2.00	-1.62	5.99	6.41	5.16	4.91
North America:						
Supply	10.98	11.11	9.22	10.16	10.07	10.19
Demand	10.85	11.12	4.35	4.60	4.85	5.30
Balance	0.13	-0.01	4.87	5.56	5.22	4.89
Western Europe:						
Supply	9.71	9.91	4.94	4.91	5.15	5.22
Demand	11.10	10.60	5.00	5.00	5.43	5.43
Balance	-1.39	-0.69	-0.06	-0.09	-0.28	-0.21
Oceania:						
Supply	0.34	0.40	1.50	1.60	0.00	0.00
Demand	0.40	0.48	1.06	1.22	0.23	0.28
Balance	-0.06	-0.08	0.44	0.38	-0.23	-0.28
Other countries:						
Supply	0.43	0.33	1.81	1.79	1.20	1.31
Demand	1.11	1.16	1.07	1.24	0.76	0.80
Balance	-0.68	-0.83	0.74	0.55	0.44	0.51
Developing market economies:						
Supply	17.09	21.70	8.46	9.83	0.66	0.83
Demand	18.19	22.88	9.14	11.37	4.24	5.41
Balance	-1.10	-1.18	-0.68	-1.54	-3.58	-4.58
Africa:						
Supply	0.43	0.62	3.64	4.17	0.00	0.00
Demand	0.92	1.13	0.68	0.85	0.33	0.41
Balance	-0.50	-0.51	2.96	3.32	-0.33	-0.41
Latin America:						
Supply	4.03	5.00	1.91	2.22	0.01	0.07
Demand	3.95	4.68	2.80	3.21	1.90	2.33
Balance	0.08	0.32	-0.89	-0.99	-1.89	-2.26
Near East:						
Supply	3.54	4.54	1.18	1.43	0.65	0.76
Demand	2.92	3.57	1.66	2.16	0.16	0.21
Balance	0.62	0.97	-0.48	-0.73	0.49	0.55
Far East:						
Supply	9.10	11.53	1.73	2.02	0.00	0.00
Demand	10.40	13.50	4.00	5.15	1.85	2.46
Balance	-1.30	-1.97	-2.27	-3.13	-1.85	-2.46
Centrally planned countries of Asia:						
Supply	13.46	14.49	3.16	3.46	0.03	0.07
Demand	15.85	18.30	3.80	4.50	1.10	1.62
Balance	-2.39	-3.81	-0.64	-1.04	-1.07	-1.55
Eastern Europe and the Soviet Union:						
Supply	23.05	24.87	9.68	10.76	12.67	13.80
Demand	16.34	19.00	11.42	12.87	9.93	10.54
Balance	6.71	5.87	-1.74	-2.11	2.73	3.26
WORLD TOTAL:						
Supply	75.06	82.79	38.77	42.52	29.78	31.41
Demand	73.84	83.54	35.84	40.80	26.54	29.38
Balance	1.22	-0.75	2.93	1.72	3.24	2.03

1/ Forecasts for year ending June 30.

Source: (4).

LIST OF TABLES

APPENDIX TABLES

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